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PAYLOAD DATA PROCESSING DRIVERS FOR THE DATA
SYSTEM NEW TECHNOLOGY STUDY (IBM Federal
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SELECTION OF SHUTTLE PAYLOAD DATA PROCESSING DRIVERS
FOR THE DATA SYSTEM NEW TECHNOLOGY STUDY

ASTRONOMY
HIGH ENERGY ASTROPHYSICS
EARTH OBSERVATIONS
EARTH AND OCEAN PHYSICS
COMMUNICATION/NAVIGATION
LUNAR

IBM
FEDERAL SYSTEMS DIVISION
HOUSTON

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TABLE OF CONTENTS

	<u>Page</u>
1. INTRODUCTION AND SUMMARY.	1- 1
2. TECHNOLOGY PAYLOAD TRAFFIC MODEL.	2- 1
2.1 Introduction and Summary.	2- 1
2.2 Groundrules for Developing the Payload Traffic Model.	2- 1
3. PAYLOAD WEIGHTING FOR DRIVER SELECTION.	3- 1
3.1 Steps in the Weighting Process.	3- 1
3.2 Processing Functions and Their Weights.	3- 2
3.3 Weights for Each Payload.	3- 5
3.4 Weighting of Processing Blocks and the Net Score.	3- 5
3.5 Discipline Weights.	3- 8
3.6 Summary of Weights Combination.	3- 8
4. DRIVER SELECTION PROCESS.	4- 1
5. ASTRONOMY AND HIGH ENERGY ASTROPHYSICS DRIVER SELECTION	5- 1
5.1 Astronomy Free Flier Data Volumes	5- 1
5.2 High Energy Astrophysics Free Flier Data Volumes.	5- 2
5.3 Astronomy Free Flier Weights.	5- 4
5.4 High Energy Astrophysics Free Flier Weights	5-19
5.5 Combined Astronomy and High Energy Astrophysics Free Flier Weights	5-35
5.6 Astronomy and High Energy Astrophysics Sortie Data Volumes.	5-35
5.7 Astronomy and High Energy Astrophysics Sortie Weights	5-38
5.8 Driver Payloads	5-46
6. EARTH OBSERVATIONS, EARTH AND OCEAN PHYSICS, AND COMMUNICATION/ NAVIGATION DISCIPLINES.	6- 1
7. LUNAR EXPLORATION PROGRAM	7- 1
7.1 Payload Descriptions and Data Volumes	7- 1
7.2 Profiles for Driver Selection	7- 5
8. SUMMARY OF DRIVER PAYLOADS.	8- 1
9. REFERENCES.	9- 1

1. INTRODUCTION AND SUMMARY

The search for technology limitations in Shuttle payload data processing requires both a broad investigation of payloads in general to insure completeness in the search and an in depth analysis on selected payloads to adequately characterize and establish a firm basis for the limitations found. The selected payloads characterize and envelope the data handling requirements of all payloads; that is, they are data system drivers. The present report describes the broad investigation of all payloads in the IBM disciplines and the selection of driver payloads within each discipline.

The driver payloads are selected on the basis of their data processing requirements. These requirements are measured by a weighting scheme described in Section 3. The total requirements for each discipline are estimated by use of the Technology Payload Model of Reference 1, as interpreted in Section 2. Section 4 describes the driver selection process which was both a payload-by-payload comparison and a comparison of expected groupings of payloads. The processes described in Sections 3 and 4 are carried out for the astronomy and high energy astrophysics disciplines in Section 5; for the earth observation, earth and ocean physics, and communication/navigation disciplines in Section 6; and for the lunar discipline in Section 7. The fifteen drivers selected are summarized in Section 8.

2. TECHNOLOGY PAYLOAD TRAFFIC MODEL

2.1 Introduction and Summary

Reference 1 presents the basic payload model to be used in the data processing new technology study. The model gives the number of Shuttle flights per year required to deliver, retrieve, and service (visit) payloads but not the number of each payload actually on orbit. In order to estimate the data loads imposed by the free fliers, it is necessary to translate the data given in Reference 1 into schedules giving the numbers of payloads operating at any time.

The required translation was performed, and the resulting traffic model is presented in Tables 2-1 through 2-6 for the six IBM disciplines. The remaining disciplines are represented in Tables 2-7 through 2-11 for information purposes only. The tables summarize the delivery / retrieval / visit schedule (up, down arrows and v's, respectively) for each payload and the number of each payload in orbit and operating within each of the years from 1977 to 1991. The discipline totals are also represented at the bottom of each table, and they are summarized in Table 2-12.

2.2 Groundrules for Developing the Payload Traffic Model

Several guidelines were followed as noted below:

1. Based on the Technology Payload Model (TPM) (Reference 1) and the 1973 SPDA (Reference 2). SPDA shows launches only, and some of those launches are apparently visits only and not payload insertions. TPM breakdown (Reference 3) allows a more accurate count of P/L's actually on orbit, since retrievals are shown. In general, the SPDA agrees with the TPM regarding launch schedules.

2. Payloads are ordered in disciplines by the SPDA descriptor rather than the TPM descriptor. This necessitated breaking some payloads down into subgroups. For example, the AST 1 payload is comprised of the AS-02-A, AS-03-A, and AS-05-A payloads.
3. Payload lifetime is generally ignored, assuming that if a payload is up, it is operating. The reasoning behind this is to remain consistent with the retrieval schedule of the TPM breakdown. (P/L is operating until retrieved), Exceptions to this general rule are EO-17-A, AS-02-A, and interplanetary payloads, the latter using mission operation timelines inferred from the SPDA.
4. P/L AS-02-A is heliocentric, hence no retrievals. Since a 2 year lifetime and 2 year launch intervals are given, it is assumed that one P/L is active at a time. All retrievals for AST 1A were assigned to AS-03-A, AS-21-A, AS-22-A and AS-24-A. (divided, with early retrievals going to pre 1980 launches, late retrievals going to AS-03-A).
5. Retrievals were divided between CN-55-A and CN-60-A, consistent with the latter series supplementing the former.
6. The indicated number of payloads on orbit generally reflects the year end status.
7. PHY 1 divided among HE-07-A, AP-01-A, AP-02-A, AP-03-A as follows:

PHY1A - One launch given to HE-07-A, basic launch, retrieval schedule used as is. Three of the launches and the basic launch, retrieval schedule used for AP-01-A. In other words, the basic launch

and retrieval schedule is used for both HE-07-A
and AP-01-A, with the initial total on orbit (4)
being divided between the two missions:

PHY 1B - Assigned to AP-02-A intact.

PHY 1C - Assigned to AP-03-A intact.

TABLE 2-1 ASTRONOMY FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	PAYLOAD NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
AS 01 A	AST 6	LGE. SPACE TEL.															
		No. on Orbit															
AS 02 A	AST 1A	LYMAN α EXPLORER															
		No. on Orbit															
AS 03 A	AST 1A	COSMIC EXPLORER															
		NO. on Orbit															
AS 05 A	AST 1B	ADV. RADIO EXPL.															
		No. on Orbit															
AS 16 A	AST 8	LGE. RADIO ARRAY															
		No. on Orbit															
	1053	IR Interferometer															
		No. on Orbit															
	1054	LGE. CRYO. IR TEL.															
		No. on Orbit															
	1055	MICROWAVE LBI															
		No. on Orbit															
	1072	LGE. AMB. IR TEL.															
		No. on Orbit															
	1073	SUBMILLIMETER TEL.															
		No. on Orbit															
AS 21 A	AST 1A	INTERNATL UV EXPL(IUE)															
		No. on Orbit															
AS 22 A	AST 1A	RADIO EXPL (SYNC ORB)															
		No. on Orbit															
AS 24 A	AST 1A	IUE PHOTOMETRY															
		No. On Orbit															
DISCIPLINE TOTAL ON ORBIT			2	3	4	6	6	6	8	8	13	12	14	13	13	12	12
* One on Orbit already																	

TABLE 2-2 HIGH ENERGY ASTROPHYSICS FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
HE 01 A	AST 9B	LGE X RAY TEL. No. on Orbit										†		v		v	†
HE 03 A	AST 5(A)	EXT X RAY SURVEY No. on Orbit						†	v		v	†					
HE 05 A	AST 5(B)	HI LAT COSMIC No. on Orbit						1	1	1	1	0					
HE 07 A	PHY 1A	SMALL HEO No. on Orbit	†				†			††					†	††	††
HE 08 A	AST 5(C)	LGE HEO-A No. on Orbit	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3
HE 09 A	AST 4(B)	LGE HEO-B No. on Orbit				†3							†	v		v	†
HE 10 A	AST 5(D)	LGE HEO-C No. on Orbit												1	1	1	1
HE 11 A	AST 9A	LGE HEO-D No. on Orbit							†	v	v		†				
HE 12 A	PHY 5	COSMIC RAY LAB No. on Orbit							1	1	1	1	0				
HE 23 A	AST 4(A)	HI NRG ASTR OBS No. on Orbit			†	†								†	v	v	v
					1	0								1	1	1	1
DISCIPLINE	TOTAL ON ORBIT		1	1	2	4	5	6	7	7	7	8	9	10	10	9	10

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TABLE 2-3 EARTH OBSERVATIONS FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
EO-07-A		ADV. SYNC. MET. SAT.	†										†				
		No. on Orbit	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
EO 08 A(1)	EO 3A	EOS	†					†	†		†	†				†	†
		No. on Orbit	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0
EO 08 A(2)	EO 3B	EOS		†				†	†		†		†				
		No. on Orbit		1	1	1	1	0	0	1	1	0	0	1	1	1	1
EO 08 A(3)	EO 3C	EOS					†			†	†				†		†
		No. on Orbit					1	1	1	1	0	1	1	1	0	0	1
EO 08 A(4)	EO 3D	EOS				†											
		No. on Orbit				1	1	1	1	1	1	1	1	1	1	1	1
EO 09 A(1)	EO 4A	SYNC. EOS						†	†		†	†					
		No. on Orbit						1	1	2	2	3	2	2	2	2	2
EO 09 A(2)	EO 4B	SYNC. EOS											†2		†2		†2
		No. on Orbit											2	2	4	4	6
EO 10 A(1)	EO 5A	SPEC. PURP. OBS. SAT.				†											
		No. on Orbit				1	1	1	1	1	1	1	1	1	1	1	1
EO 10 A(2)	EO 5B	SPEC. PURP. OBS. SAT.				†											
		No. on Orbit				1	1	1	1	1	1	1	1	1	1	1	1
EO 10 A(3)	EO 5C	SPEC. PURP. OBS. SAT.				†2				†			†			†	
		No. on Orbit				2	2	2	3	3	3	4	4	4	5	5	
EO 10 A(4)	EO 5D	SPEC. PURP. OBS. SAT.						†			†			†			†
		No. on Orbit						1	1	1	2	2	2	3	3	3	4
EO 10 A(5)	EO 5E	SPEC. PURP. OBS. SAT.							†			†			†		
		No. on Orbit							1	1	1	2	2	2	3	3	3
EO 12 A	EO 6	TIROS O	†					†		†			†v				
		No. on Orbit	1	1	1	1	1	2	2	1	1	1	2	2	2	2	2
EO 15 A		STORMSAT				†		†									
		No. on Orbit				1	1	2	2	2	2	2	2	2	2	2	2
EO 17A		EOS A	†														
		No. on Orbit	1	1													
EO 56 A	N/ND B	ENV. MON. SAT.				†	†	†		†3	†	†	††	††	†	††	†
		No. on Orbit				1	2	3	3	0	1	2	2	2	1	1	2

TABLE 2-3 EARTH OBSERVATIONS FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
EO 57 A	N/ND-9	FOR. SYNC. MET. SAT. No. on Orbit	+				+	+		++	+	++		++		++	
EO 58 A	N/ND 10	GEOSYNC OP. ENV. SAT. No. on Orbit	+	+	+		+	+	+	+3	++	+	++	+	++		+
EO 59 A	N/ND 12	SYNC. EARTH RESCR. No. on Orbit	1	2	3	3	4	5	6	3	3	2	2	3	3	3	3
EO 61 A	N/ND 11	ERS OS No. on Orbit					+	+	+	+2	++	++	++	++	++	++	++
EO 62 A	N/ND 13	FOREIGN SEOS No. on Orbit	3	4	5	6	5	5	5	5	5	5	5	5	5	5	5
														+	+2		+
														1	3	3	4
	2019, 2020	ADV. NRG. BUD. MON No. on Orbit												+3	+3	v	
														3	6	6	6
DISCIPLINE	TOTAL ON ORBIT		2	7	9	17	25	31	33	27	29	29	37	45	49	52	57

TABLE 2-4 EARTH AND OCEAN PHYSICS FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
OP 01 A	EOP 4	GEOPAUSE															
		No. on Orbit	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
OP 02 A	EOP 5	GRAV. GRADIOMETER															
		No. on Orbit															
OP 03 A(1)	EOP 6 A	MINI LAGEOS															
		No. on Orbit															
OP 03 A(2)	EOP 6 B	MINI LAGEOS															
		No. on Orbit															
OP 03 A(3)	EOP 6 C	MINI LAGEOS															
		No. on Orbit															
OP 04 A	EOP 7	GRAVSAT															
		No. on Orbit															
OP 05 A	EOP 8	VECTOR MAGN. SAT.															
		No. on Orbit															
OP 06 A	EOP 9	MAG FLD. MON. SAT.															
		No. on Orbit															
OP 07 A	EOP 3	SEASAT - B															
		No. on Orbit															
OP 51 A	N/ND 14	GBL. EARTH/OCEAN															
		No. on Orbit															
	2027, 2028	SEA SURVEY SYST.															
		No. on Orbit															
	2029	HI RES SEA SURVEY															
		No. on Orbit															
	2041	EARTHQUAKE PRED. SYST.															
		No. on Orbit															
DISCIPLINE	TOTAL ON ORBIT		1	2	8	13	14	11	10	20	25	22	26	23	30	29	

TABLE 2-5 COMMUNICATIONS / NAVIGATION FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
CN 51 A	N/ND1	INTELSAT	+	+	+	+3			+2	+3	+2	+2	+	+	22	33	+2
		No. on Orbit	2*	3	4	7	7	7	9	12	14	16	15	14	14	14	16
CN 52 A	N/ND2A	DOMSAT A		+3	+	+2	+2	+									
		No. on Orbit		3	4	6	8	9	9	9	9	9	9	9	9	9	9
CN 53 A	N/ND2B	DOMSAT B								+	+	+2	+2	+3	+2	+2	
		No. on Orbit								1	2	4	6	9	11	13	14
CN 54 A	N/ND3	DISASTER WNG. SAT.					+	+			+	+	+			+	
		No. on Orbit					1	2	2	2	3	2	1	1	1	2	2
CN 55 A	N/ND4	TRAFFIG MGMT. SAT.		+2	+2	+	+	+	+					+		+	
		No. on Orbit		5	7	9	10	11	12	12	13	13	14	14	15	15	
CN 56 A	N/ND5(A)	FOREIGN COM SAT.			+	+	+	++	+								
		No. on Orbit			1	2	3	3	2	2	2	2	2	2	2	2	2
CN 58 A	N/ND2C	DOMSAT C						+3						+3			
		No. on Orbit		3	3	3	3	6	6	6	6	6	6	9	9	9	9
CN 59 A	N/ND6	COM. R&D PROTO.									+			+		+	
		No. on Orbit									1	1	1	2	2	3	3
CN 60 A	N/ND5(B)	FOREIGN COM. SAT.									+	+	+	++	++	++	++
		No. on Orbit									1	2	3	3	3	3	3
	1001, 1002	GLOBAL POSIT. SYST.						+	+		v		+	+	v		
		No. on Orbit						1	2	2	2	2	3	4	4	4	4
	1027	PERSONAL COM. SYST.														+	
		No. on Orbit														1	1
DISCIPLINE TOTAL ON ORBIT			2	3	15	21	27	33	42	47	52	57	59	67	69	75	78
* One already on Orbit																	

TABLE 2-6 LUNAR FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
LU01 A	LUN 2	LUNAR ORBITER									+		+				
		No. on Orbit									1	1	2	2	2	2	2
LU02 A	LUN 3	LUNAR ROVER												+	+		
		No. on Orbit													2	2	2
LU03 A	LUN 4	LUNAR HALO SAT.															
		No. on Orbit														1	1
LU04 A	LUN 5	LUNAR SAMPLE RET.															
		No. on Orbit															1
LU05 A	LUN 1	LUNAR POLAR ORB.									+						
		No. on Orbit									1	1	1	1	1		2
DISCIPLINE TOTAL ON ORBIT											1	1	1	1	1	2	3
															4	5	6
																7	

TABLE 2-7 SOLAR PHYSICS FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
SO 02 A	AST 7	LGE SOLAR OBS										+	v	v	v	v	v
		No. on Orbit										1	1	1	1	1	1
SO 03 A	AST 3	SOLAR MAX MISS.			++		++		++		++		++		++		
		No. on Orbit	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DISCIPLINE TOTAL ON ORBIT			1	1	1	1	1	1	1	2	2	2	2	2	2	2	2

TABLE 2-8 ATMOSPHERIC AND SPACE SCIENCE FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
AP01 A	PHY 1A	UPPER ATM. EXPL.	+3				+		++					+	++	++	++
		No. on Orbit	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5
AP02 A	PHY 1B	MED. ALT. EXPL.			+		+		++					+	++	++	++
		No. on Orbit			1	1	2	2	2	2	2	2	2	3	3	3	3
AP03 A	PHY 1C	HI ALT. EXPL.				+		+	+		+	+	+				
		No. on Orbit				1	1	2	3	3	4	5	6	6	6	6	6
AP04 A	PHY 2A	GRAV/REL. SAT.-LEO			+				+								
		No. on Orbit			1	1	1	2	2	2	2	2	2	2	2	2	2
AP05 A	PHY 3A	ENV. PERT. SAT-A					+		++								
		No. on Orbit					1	1	1	1	1	1	1	1	1	1	1
AP06 A	PHY 2B	GRAV/REL. SAT.										+					+
		No. on Orbit										1	1	1	1	1	2
AP07 A	PHY 3B	ENV. PERT. SAT-B											+		++		
		No. on Orbit											1	1	1	1	1
AP08 A	PHY 4	HEL. AND INSEL												+			
		No. on Orbit												1	1	1	1
DISCIPLINE TOTAL ON ORBIT			3	3	4	6	9	10	12	12	13	15	17	20	20	20	21

TABLE 2-9 LIFE SCIENCES FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
LS 02 A	LS-1	BESS															
		No. on Orbit															
DISCIPLINE	TOTAL ON ORBIT																

TABLE 2-10 SPACE TECHNOLOGY FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
ST 01 A	ST 1	LDEF No. on Orbit	↔ ↔ ↔ ↔ ↔ ↔ 1 0 1 0 1 0 1 0 1 0 1 0

TABLE 2-11 PLANETARY FREE FLIER TRAFFIC MODEL

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
PL 01 A	PL 7	MARS SS PROBE								+2							
		No. on Orbit								2	2	2					
PL 02 A	PL 8	MARS SURF. SAMPLE RET.														+	+
		No. on Orbit														1	2
PL 03 A	PL 10	PIONEER VENUS MULTIPRB				+	+2		+			+					
		No. on Orbit				1	2		1			1					
PL 07 A	PL 11	VEN. RADAR MAPPER							+2								
		No. on Orbit							2	2							
PL 08 A	PL 12	VEN. BUOY. PROBE										+2					
		No. on Orbit										2	2				
PL 09 A	PL 13	MARINER MERC. ORB.												+2			
		No. on Orbit												2	2	2	2
PL 10 A	PL 14	VEN. LGE. LANDER														+2	
		No. on Orbit														2	2
PL 11 A	PL 18	PION. SAT/URAN FLYBY						+									
		No. on Orbit						1	1	1	1	1	1				
PL 12 A	PL 19	JUPITER ORBITER						+2									
		No. on Orbit						2	2	2	2						
PL 13 A	PL 20	PION. JUP. PROBE										+2					
		No. on Orbit										2	2				
PL 14 A	PL 21	MARINER SAT. ORB.										+2					
		No. on Orbit										2	2	2	2	2	
PL 15 A	PL 22	URN PRB./NEP. FL.												+2			
		No. on Orbit												2	2	2	2
PL 16 A	PL 23	GANYMED ORB./LD.														+	+
		No. on Orbit														1	2
PL 18 A	PL 26	ENCKE REND.						+2									
		No. on Orbit						2	2	2							
PL 19 A	PL 27	HALLEY FLYBY															
		No. on Orbit															

TABLE 2-11 PLANETARY FREE FLIER TRAFFIC MODEL (cont-d)

SPDA CODE	TPM CODE	NAME	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
PL 20 A	PL 28	ASTEROID REND.										+2					
		No. on Orbit										2	2				
PL 21 A	PL 25	ENCKE SLOW FLYBY			†												
		No. on Orbit			1												
PL 22 A	PL 17	PIONEER SAT. PROBE				†											
		No. on Orbit				1	1	1									
DISCIPLINE	TOTAL ON	ORBIT	1	2	8	6	8	9	10	12	8	6	8	8	8		

3. PAYLOAD WEIGHTING FOR DRIVER SELECTION

The degree to which a payload will require new data processing technology depends upon 1) the degree to which the payload requires data handling support and 2) the degree to which present or reasonably projected state of the art data processing hardware and software technology can satisfy those requirements. Factor (1) can be inferred roughly from descriptions of the payloads and their objectives, while estimation of Factor (2) requires configuring a data handling system. It is assumed that preliminary selection of technology drivers can be performed based upon a knowledge of the requirements or Factor (1) only.

The present section is concerned with the way in which the data processing requirements are to be estimated, a process to be carried out in the form of payload weighting. The process is a subjective one in the sense that a series of relative weights is to be estimated based on value judgements, and a scheme is required to minimize the impact of subjective prejudice. The scheme adopted tends to compartmentalize the thinking of the analyst so that he will not let judgement in one part of the process influence that in another.

3.1 Steps in the Weighting Process

The ultimate purpose is to determine the net weight of a payload or group of payloads with respect to all facets of data handling. In order to avoid confusion in judgement and to focus attention on each significant facet, two important divisions were made: 1) division of processing into individual functions and 2) division of weighting into function-to-function weighting and payload-to-payload weighting. The function-to-function weighting compares each function to the others without concern for the payloads. The payload-to-payload weighting compares each payload to all others for each function, one at a time. A third important facet of the procedure is to judge the weight on a per bit basis when practical so that the judgement is not influenced by the estimated

data volume, a factor which can be separately determined by more objective means. A measure of the degree to which a payload requires or utilizes a given function is the product of the payload weight, the function weight, and, when applicable, the payload data volume. With these basic ideas in mind the detailed weighting scheme was developed as described in the subsequent subsections.

3.2 Processing Functions and Their Weights

The processing functions required for all payloads are identified in Table 3-1. The names identified are generic, and the actual structure of the function may vary from payload to payload. For example, "radiometric correction" means conversion of sensor units to engineering units, and "geometric correction and registration" may mean time synchronization or spectrum wavelength linearization as well as the normal geometric distortion correction associated with imagery.

The functions have been grouped into six categories, hereafter referred to as "blocks", as indicated in Table 3-1. All processes within a block are expected to have basically the same user and data dependences and about the same turnaround times. For the earth observations and earth and ocean physics disciplines the analysis block is not broken down into individual processes, and the analysis weight is set equal to the total preprocessing weight (exclusive of image digitization).

Each process was weighted as follows. The simplest operations respectively within the premission block, the real time operations block, and the combined real time data handling, quick look, preprocessing, and analysis blocks, were given a weight of one. Then, within each of the aforementioned groupings the other processes were weighted in terms of the simplest one. Thus, the process weights in each of the first two blocks are correlated within each block but not from block to block. All processes in the last four blocks are correlated

TABLE 3-1 PROCESSING FUNCTIONS AND THEIR WEIGHTS

Premission

- 6 Mission planning
- 6 Data processing system development, testing, configuration control, debugging, etc. support
- 2 Operations training support (simulators, etc.)
- 1 Sensor design and development support
- 2 Sensor calibration, lab testing support

Real Time Operations

- 6 Pointing and line of sight guidance
- 1 Experiment monitoring and control

Real Time Data Handling

- 1 Pre-transmission data sequencing, buffering, interleaving, transmission/onboard storage
- 2 Demultiplexing, stripping, formatting, merging

Quick Look

- 14 Quality assurance/evaluation, performance evaluation/verification, information acquisition verification

Preprocessing

- 10 Geometric correction, registration
- 2 Radiometric correction
- 6 Image editing
- 4 Filtering, apodization, compression
- 12 Fourier analysis (transforms, spectral decomposition)
- 2 Archival, copying, distribution
- 8 Image digitization (e.g. film densitometry)

TABLE 3-1 PROCESSING FUNCTIONS AND THEIR WEIGHTS (cont'd)

Analysis (For all disciplines except earth observations and earth and ocean physics. For them, the analysis weight is 36.)

- 30 Classification
- 8 Spectrum analysis (line widths, profiles, wavelengths, etc.)
- 8 Temporal analysis (variation profiles, image matching, spectrum matching)
- 30 Abundance, composition, structure determination
- 15 Morphology
- 8 Orbit determination
- 6 Polarization analysis
- 3 Angular size/diameter
- 4 Soil bearing, adhesion, cohesion strength analysis
- 15 Lunar stratigraphy (seismic, etc.)
- 6 Miscellaneous

among those blocks. At this point, the number of data to be processed by each function has not been accounted for, and the weights represent essentially per sample or per bit estimates.

3.3 Weights for Each Payload

The degree to which a given process is required by a payload depends upon the payload's activity timeline and upon the relative apportionment of time among its sensors. A weight for each payload and each process is selected as an estimate of that degree. The weight also serves to account for occasional differences from payload to payload in the utilization per bit of a given process. For example, the number of computer operations, or the degree of utilization, to perform a Fourier transform on N data points is proportional to $N \log_2 N$; hence the number of operations per sample (or equivalently per bit) is proportional to $\log_2 N$, rather than being constant. Thus, the per bit degree of utilization of Fourier transformation is a function of the data volume itself, and the effect can be roughly accounted for in the selection of the payload weight.

The weights are chosen relative to an estimated average payload. The following values of the payload weight were used:

- 3 payload's utilization is significantly above average
- 2 utilization is average
- 1 utilization is significantly below average
- 0 the function is not utilized at all

In later sections, tables of these weights for each discipline are presented. If there are N payloads and M processes, each table contains NM weights.

3.4 Weighting of Processing Blocks and the Net Score

The relative weight of each block is determined by summing over the functions of the block the products of payload and process weights for each payload. The result for N payloads is a matrix of $6N$ weights for the six blocks. The premission and real time operations blocks of Table 3-1 are presumed not to be

a function of the payload's output scientific data volume. In a strict sense, the second block's weight depends upon the housekeeping data volume and, for rigorously pointed instruments in astronomy and high energy astrophysics, the aspect camera data volume. However, these volumes appear to be similar enough from payload to payload that the real time operations functions can be measured totally by the payload weights assigned. The weights for the last four blocks of Table 3-1 were selected on a per bit basis, and the block weights obtained above are multiplied by the payload's scientific data volume to produce weights useful to compare all payloads for those blocks.

A gross figure of merit for each payload is obtained by a judicious combination of all six blocks; however the premission and real time operation blocks do not depend on the data volume as do the others. The adopted procedure for combination is to scale the weights in the first two blocks appropriately so that they may be added along with the last four blocks to produce a net score. Scaling is accomplished by comparing the number of instructions per unit time performed by each of the first two blocks to the corresponding number for radiometric correction for an average payload. For average radiometric correction, a linear transformation is assumed requiring one multiply and one add per sample. A multiply is assumed equivalent to three basic instruction units, and an add is one such unit; therefore four instruction units are required per sample. A 20% margin is added for data transfer, etc., yielding five instructions per sample, and if ten bits per sample average is assumed the resulting radiometric correction factor is $1/2$ instruction per bit.

Based on Skylab experience, it is estimated that ~2000 hours of computer time on a 1 megainstruction-per-second (MIPS) computer are required to plan 20 missions (Reference 4). It has been estimated that to break even financially the Shuttle must handle ~2.5 payloads per mission; thus roughly $2000 \text{ hr}/20 \text{ missions}/2.5 \text{ payloads} = 40 \text{ hr}$ of 1 MIPS computer time, equivalent to 1.44×10^8 instructions, are required per payload to plan a mission. It is estimated that most of the mission planning is done in the last two years before

the mission; therefore $1.44 \times 10^{12}/2 = .72 \times 10^{12}$ instructions per year are required then. If that payload also requires radiometric correction performed on N bits of scientific data per year the scale factor α required to normalize the mission planning weight to the radiometric correction weight is found from the proportion

$$\frac{1.44 \times 10^{12}/2 \text{ year}}{.5N \text{ (instr/yr)}} = \frac{W_{MP} F_{RC} \alpha_1}{W_{RC} F_{RC} N} \quad (1)$$

where W and F are the payload and process weights, respectively, and MP and RC refer to mission planning and radiometric correction, respectively. Equation (1) states that the numbers of instructions per year should be in the same proportion as the scaled weights. The scale factor α_1 can also be interpreted as an equivalent data volume. The 2 yr factor on the left hand side can be interpreted as either the number of years for mission planning or the number of years worth of scientific data (i.e., 2 yr $\times$ N) to be processed on one computer. For an average payload $W_{MP} = W_{RC} = 2$; from Table 3-1 $F_{MP} = 6$ and $F_{RC} = 2$; therefore $\alpha_1 = .05 \times 10^{12}$.

To scale the real time operations block, the real time pointing is compared to radiometric correction in the same manner. A pointing discussion for telescopes was provided in Reference 5, in which it was estimated that 10^4 sets of computations would be performed for matching ten stars between the aspect sensor image and the desired (internally generated) star field. On the average it is assumed that only $10^{12}/2$ such sets are executed but that inclusion of the pointing control algorithm and data transfer doubles the effective number of calculations. Each set requires four multiplies and four adds or equivalently 16 instruction units per set. Three sets are assumed per orbit, 16 orbits per day are assumed; therefore 10^{12} instructions per year are performed. The desired scale factor is obtained from a proportion similar to Equation (1), viz,

$$\frac{10^{12}}{.5N} = \frac{W_P F_P \alpha_2}{W_{RC} F_{RC} N} \quad (2)$$

Again $W_P = W_{RC} = 2$, and from Table 3-1, $F_P = 6$ and $F_{RC} = 2$; thus $\alpha_2 = .7 \times 10^{12}$.

Thus, the net score for each payload is obtained by the sum of products of block weights with effective data volumes, viz. α_1 and α_2 for the first two blocks, respectively, and the actual scientific data volume per year for the last four blocks.

3.5 Discipline Weights

Besides obtaining the net score of the previous subsection, the main reason for quantification of the payload requirements is to allow combination over all payloads operating concurrently to determine the magnitude of each requirement for the whole discipline. At this point the free fliers and sorties are separated as proposed in Reference 1. The payload grouping implied for free fliers is the set of all operating during a year, and that for the sorties is the candidate grouping of instruments for any one sortie flight. The free flier groupings are identified by Tables 2-1 to 2-6. The sortie groupings will be described for each discipline in later sections.

The magnitude of each requirement for those groupings is to be expressed as a weight for each block for each year. That weight is obtained by summing the products of the weight of each payload and either the number of that payload operating that year, as obtained from Table 2-1 to 2-6, or the number of that payload included in a sortie flight. In the case of the free fliers 12 years of weights are to be obtained for each of the six blocks.

3.6 Summary of Weights Combination

Let:

- F(process) = weight for each function (process) of Table 3-1
- W(process,P/L) = weight (0,1,2, or 3) for each payload and each process, described in Section 3.3
- V(P/L) = yearly data volume (units of 10^{12} bits/yr) of each payload
- N(P/L,t) = number of each free flier payload operating during a year (t), as obtained from Tables 2-1 to 2-6.

$N(P/L, m)$ = number of each sortie payload operating in a sortie mission (m)

$M(P/L, t)$ = number of Shuttle flights/year for a payload from Tables 2-1 to 2-6.

The various weighted sums are obtained as follows:

Block weight: $W(\text{block}, P/L) = \sum_{\text{processes in each block}} W(\text{process}, P/L) F(\text{process})$

Net score: $S(P/L) = .05W(\text{Block 1}, P/L) + .7W(\text{Block 2}, P/L) + V(P/L) \sum_{\text{Blocks 3-6}} W(\text{block}, P/L)$

Discipline Free Flier Scores: $D(\text{Block}, t) = \begin{cases} \sum_{P/L's} .05M(P/L, t)W(\text{Block 1}, P/L) \\ \sum_{P/L's} .7N(P/L, t)W(\text{Block 2}, P/L) \\ \sum_{P/L's} V(P/L)N(P/L, t)W(\text{Block}, P/L) \end{cases}$ Blocks 3 - 6

Discipline Sortie Scores: Same as above with t replaced by m.

4. DRIVER SELECTION PROCESS

In the previous section two sets of criteria, viz a payload net score and a set of discipline group scores, were developed to aid in choosing the driver payloads. The adopted selection process utilizes both sets of criteria and is to be performed on a discipline by discipline basis. A notable exception will be discussed later for astronomy and high energy astrophysics.

The two sets of criteria are utilized as follows. First, all payloads in a discipline are ranked according to the net score. Rather than merely selecting the highest payloads in the ranking, the second set of criteria is utilized by selecting driver groupings of payloads from which individual payloads are extracted as drivers. The purpose of the second selection is to account for payloads which, by themselves, do not appear to drive the data system but which come to the forefront by virtue of their presence in a significant group. The driver groups are selected on the basis of their net data volumes and their discipline scores obtained within each of the processing blocks, as described in the previous section. For the free fliers driver years are selected, and the driver group is comprised of all payloads operating that year, as provided in Tables 2-1 to 2-6. For the sorties, driver flights are chosen. Generally, a free flier driver year is selected as the year in which a peak occurs in the net data volume or discipline score; however in some cases a year in which a significant rise is noted qualifies. The rationale for the latter selection is the fact that a sudden jump in data system requirements, especially early in the Shuttle program, may exceed the buildup capability of the data system. Specific cases will be described in more detail in later sections.

After the driver groups are selected, individual driver payloads within a group are chosen based upon 1) their relative data volumes, 2) the degree to which they represent generically all other payloads in their group, 3) the frequency with which they occur in all the driver groups, and 4) their weights within each block.

The drivers obtained from the groups are compared to the drivers obtained from the net score ranking, and a final set of drivers is selected for each discipline. Although the specifics of this selection process are reserved for later sections, it is noted here that in the disciplines examined there was always a close similarity between the sets of drivers obtained from the ranking and those chosen from the groups.

5. ASTRONOMY AND HIGH ENERGY ASTROPHYSICS DRIVER SELECTION

The concepts developed in the previous two sections are applied to the astronomy (AS) and high energy astrophysics (HE) disciplines in this section. The disciplines are considered together because they may share the same control and data processing centers, and, in fact, a combined AS and HE grouping is considered later in this section. Determination of the data volumes, not yet discussed, is described in the greatest detail in the next two sections. The weighting process is a straightforward application of the precepts presented earlier.

5.1 Astronomy Free Flier Data Volumes

The data volumes are summarized payload by payload below. At this early stage in the sensor development few concrete data are available, and it was necessary to make certain assumptions. The assumptions and the outside sources of data are explicitly stated. Frequently the SPDA (References 1, 6, and 7) were utilized. It was noted that the SPDA values for ultraviolet and visible spectrum sensors are misleading in that the readout data rate is given rather than the average data collection rate. The error is especially significant when an integrating device, such as a vidicon, is used because the frame may be exposed for a considerable time. No problem is apparent in the reported rates for infrared and radio frequency instruments whose detectors are continuous output sources.

- o Space Telescope Field camera is data driver: 15 frames/day average $\times 2000^2$ samples/frame $\times 10$ bits/sample (data from Sobieski, GSFC) = .219E12 bits/yr. Echelle spectrograph adds small amount: 500^2 samples/frame (Sobieski, GSFC) and is negligible.
- o Extracoronat Lyman Alpha Explorer Echelle spectrograph: 1024^2 pixels/frame $\times 12$ bits/pixel $\times 30$ frames/day $\times 2$ instruments operating simultaneously (echelle + absorption cells) (data from Lane, JPL) = .274E12 bits/yr.

- o Cosmic Background Explorer 4096 bps ('74 SPDA), assume continuous output = $.128E12$ bits/yr.
- o Advanced Radio Astronomical Explorer (ARAE) 40960 bits/sec ('73SPDA) x 12 hr/day (12 - 1 hr ops - SPDA) x 2 satellites = $1.293E12$ bits/yr.
- o Large Radio Observatory Array 102400 bits/sec ('75 SPDA) x 12 hr/day (assume 12 - 1 hr ops/day) = $1.614E12$ bits/yr.
- o IR Long Base Interferometer (LBI) 81920 bps from correlator x 1.03 hr/op + 18080 bps "housekeeping" x 1.55 hr/op, sum x 15.5 ops/day (data from '73&'75 SPDA for sortie version) = $2.396E12$ bits/yr.
- o Cryogenically Cooled IR Telescope 250 kbps (Melugin, Ames: post-'85 value for interferometer) x 52 min/op ('75 SPDA) x 15.5 ops/day ('75 SPDA) = $4.420E12$ bits/yr.
- o Microwave LBI Assume same as for ARAE (35.4E8 bits/day for ARAE rounded to 35E8) = $1.278E12$ bits/yr.
- o Ambient Temperature IR Telescope 17 kbps x 1.5 hr/orbit x 15.5 orbits/day (data from SPDA for sortie version) = $.511E12$ bits/yr.
- o Submillimeter Telescope Assume same as Ambient Temperature IR Telescope = $.511E12$ bits/yr.
- o International Ultraviolet Explorer (IUE) 1E8 bits/day (Klinglesmith, GSFC) = $.036E12$ bits/yr.
- o Radio Explorer 22528 bps ('75 SPDA: 43008 bps less 20480 bps for star tracker) x 12 hr/day ('75 SPDA: 12 - 1 hr ops) = $.354E12$ bits/yr.
- o IUE Photometry Assume same as IUE = $.036E12$ bits/yr.

5.2 High Energy Astrophysics Free Flier Data Volumes

For most of the payloads a data volume was estimated based upon a brief study of the particular instruments which are used in the experiments. Also, a data volume was calculated from the SPDA data bit rate. The values obtained were different for most of the payloads. The value used for a particular payload

was selected according to the degree of understanding on which the estimate was based and according to the apparent reasonableness of the value calculated from the SPDA. Only the selected value is explained in the following.

Some instruments deliver data in a format that will result in a large compression during preprocessing. For example, some photon counting sensor arrays output the impact coordinates of each photon when it strikes. The subsequent conversion to an "image" in the form number-of-photons-per-pixel effects a substantial data reduction. For such instruments both a "preprocessing" and an "analysis" data volume are computed.

HE - 01 - A Large X-Ray Telescope Facility

The x-ray imaging experiment is the major contributor to the data volume. If we use the SPDA data rate of $3.29E4$ bits per second and assume 6 hours of operation per day, the yearly pre-processing volume is $2.6E11$ bits per year. The analysis volume is estimated based upon the study of the instruments, which indicates that the image intensifier is the driver. If we assume 2 frames of data per orbit, 16 orbits per day, 1024 pixels per line and 1024 lines, and 12 bit words, the analysis volume is $1.5E11$ bits per year.

HE - 03 - A Extended X-Ray Survey

The x-ray converter and imager and the proportional counter are the drivers on this payload. The average SPDA data rate for these instruments is $1.26E4$ bits per second. If we assume 12 hours of operation per day, the pre-processing volume is $2E11$ bits per year. The analysis volume is assumed to be $1E8$ bits per year based upon that for HE - 01 - A and the fact that the IFOV for this payload is greater by a factor of two.

HE - 05 - A High Latitude Cosmic Ray Survey

Determination of the trajectory of the incoming particle produces most of the data volume for this payload. If we assume 10^{-1} particles per second, 120 bits per particle for position description, and 10 instruments operating simultaneously, a data volume of $3.7E7$ bits per year results.

HE - 07 - A Small High Energy Satellite

The proportional counter modules are the data drivers for this payload. If we use the SPDA data rate of 2048 bits per second and assume 2 counters operating for a total of 12 hours per day, the data volume will be $6.5E10$ bits per year.

HE - 08 - A Large High Energy Observatory A (Gamma Ray)

The main source of data for this payload is the spark chamber pictorial readout. If we use the SPDA data-rate of $1E4$, the data volume is $3.2E11$ bits per year.

HE - 09 - A Large High Energy Observatory B (Mag. Spec.)

The track locator detector produces most of the data for this payload. The total SPDA data rate is $1E4$. This results in a data volume of $3.2E11$ bits per year.

HE - 10 - A Large High Energy Observatory C (Nuc.)

The spark chambers produce the highest data rate. Using the SPDA data rate of $8E^3$ gives a data volume of $2.5E11$ bits per year.

HE - 11 - A Large High Energy Observatory D (X-ray)

This payload is essentially the same as HE - 01 - A.

HE - 12 - A Cosmic Ray Laboratory

The magnetic spectrometer is the data driver. Using the SPDA data rate of $3E5$ gives a data volume of $9.5E12$.

HE - 23 - A High Energy Astronomical Observatory C

The high resolution gamma-ray spectrometer produces the greatest amount of data on this payload. Using the SPDA data rate of 6400 bits per second and assuming 12 hours per day operation give a data volume of $1E11$ bits per year.

5.3 Astronomy Free Flier Weights

The payload weights for each processing function were selected according to the scheme in Section 3 and are tabulated in Table 5-1. These weights were chosen based upon information in the SPDA, other payload specific descriptions, and from PI interviews. It should be recalled that the weights are 2, 3, and 1 for average, above average, and below average respectively, with 0 representing no requirement. For several of the processing functions the criteria exercised are generalized below:

Mission Planning - relatively low for astronomy missions

Low earth orbit - weight 1

Synchronous or heliocentric orbit - weight 2

TABLE 5-1 PAYLOAD WEIGHT MATRIX FOR ASTRONOMY FREE FLIERS

ORIGINAL PAGE IS
OF POOR QUALITY

PAYLOAD	PROCESS WEIGHT	PREMISSION					REAL TIME OPS		R.T. DATA HANDL		Q.L.		PREPROCESSING					ANALYSIS															TOTAL PAGE IS OR QUALITY
		Mission planning	DP System Devel	Sensor Training	Sensor Design Supt	Experiment Pointing / test	Pre-trans; Control	Demux, etc.	Quick Look	Image Digitization	Geom. Corr	Radiometric Corr	Image Editing	Fourier Analysis	Arch. / Distrib.	Class. / Analysis	Spectrum Anal	Temporal Anal	Abund	Morphology	Orbit / Struct	Polarization	Ang. Determ.	Soil Diam.	Stratigraphy	Miscellaneous							
		6	6	2	1	2	6	1	1	2	14	8	10	2	6	4	12	2	30	8	8	30	15	8	6	3	4	15	5				
AS-01-A SPACE TELESCOPE		1	2	3	1	3	3	3	1	2	3	0	3	3	2	2	0	2	2	3	2	3	3	3	1	1	0	0	1				
AS-02-A EXTRA COR. Lg EXPL.		2	1	1	1	2	3	2	1	1	2	0	3	3	2	1	0	1	1	3	1	3	2	3	0	0	0	0	1				
AS-03-A COSM. BKGND. EXPL.		1	2	1	1	3	2	2	1	2	2	0	1	3	1	2	1	2	2	1	1	1	2	0	1	0	0	0	1				
AS-05-A ADV. RADIO ASTR. EXP		2	1	1	2	2	2	2	1	1	2	0	1	2	1	2	2	1	0	2	0	2	1	0	2	3	0	0	1				
AS-16-A LG. RADIO OBS ARRAY		2	1	1	2	2	2	2	1	1	2	0	1	2	1	2	2	2	0	0	0	0	3	1	2	2	0	0	0				
OFS-1053 IR LBI		1	1	2	2	2	2	3	1	2	2	0	1	2	0	2	2	1	0	0	0	0	1	1	0	3	0	0	0				
OFS-1054 CYRO IR TELESC		1	2	3	2	3	3	3	1	2	3	0	2	3	2	2	2	2	1	3	2	3	3	2	1	1	0	0	0				
OFS-1055 MICROWAVE LBI		1	1	2	2	2	2	3	1	2	2	0	1	2	0	2	2	1	0	0	0	0	1	1	0	3	0	0	0				
OFS-1072 AMB TEMP IR TELESC		1	2	3	1	3	3	3	1	2	3	0	2	3	2	1	1	2	1	2	3	2	3	2	0	1	0	0	0				
OFS-1073 SUBMILLIMETER TELESC		1	2	3	1	3	2	3	1	2	2	0	1	2	2	1	0	2	1	2	1	2	2	1	0	0	0	0	0				
AS-21-A IUE		2	1	2	1	2	3	3	1	1	3	0	3	3	2	2	0	2	1	3	2	3	1	3	0	0	0	0	0				
AS-22-A RADIO EXPLORER		2	1	1	1	2	2	2	1	1	2	0	1	2	1	1	0	2	0	2	2	2	0	0	1	0	0	0	0				
AS-24-A IUE PHOTOMETRY		2	1	2	1	2	3	3	1	1	3	0	3	3	2	2	0	2	1	1	3	0	1	0	0	0	0	0	0				

DP System Development

Objective dedicated or few sensors on P/L - weight 1

Facility class payload with several sensors - weight 2

OPS Training Support

Few users - weight 1

Multi-user or LBI - weight 2

Multi-user facility class - weight 3

Sensor Design Support

Extension of ground based technology - weight 1

Special development for space - weight 2

Sensor Calibration/Testing - generally high

IR calibration or facility class - weight 3

Others - weight 2

Pointing/LOS Guidance - stringent pointing for celestial viewing

Lower angular resolution - weight 2

Higher angular resolution - weight 3

Experiment Control - not routine; therefore generally high

Facilities with several sensors or optical heterodyning - weight 3

Others - weight 2

Pre-transmission Handling, etc. - at most, two sensor data interleavings - weight 1

Demultiplexing, etc. - whether TDRSS is used

Sync. or heliocentric orbit (direct transm.) - weight 1

Low earth orbit (use TDRSS) - weight 2

Quick Look - generally average

Quick preprocessing turnaround required - weight 3

Others - weight 2

Geometric Correction/Registration

Vidicon present - weight 3

Low resolution or one-dimensional record - weight 1

Others - weight 2

Radiometric Correction

IR calibration or vidicon - weight 3

Others - weight 2

Image/Record Editing - generally average

One-dimensional record, or low spectral or spatial resolution -
weight 1

Two-dimensional imagery, high spectral or spatial resolution -
weight 2

Archival/Distribution

Few users - weight 1

Multi-user facility or survey - weight 2

Judgement of the other processing functions was very payload dependent, and generalizations cannot easily be made about it.

As described in Section 3, the process weights in Table 5-1 were multiplied by the payload weights and summed over each block. These sums for the first two blocks were multiplied by the appropriate scale factors (Section 3.4), those for the remaining blocks were multiplied by the data volumes, and the results are shown in Table 5-2. The six block weights were summed to produce the net score. The maximum number of payloads in the table reflects the greatest

TABLE 5-2 DATA VOLUMES, BLOCK WEIGHTS, AND SCORES FOR ASTRONOMY FREE FLIERS

PAYLOAD	Data Volume (10^{12} bits/yr)	Pre-mission	Real Time Ops	Real Time Data Handling	Quick Look	Pre- Processing	Analysis	Net Score Per Payload	Max. No. Pay- loads	Total Score
AS-01-A SPACE TELESCOPE	.219	1.55	14.7	1.1	9.2	13.1	58.7	98.4	1	98.4
AS-02-A EXTRA COR. LG EXPL.	.274	1.25	14.0	.8	7.7	14.2	56.4	95.0	1	95.0
AS-03-A COSM. BKGND. EXPL.	.128	1.35	9.8	.7	3.6	4.3	18.2	32.0	4	152.7
AS-05-A ADV. RADIO ASTR. EXP	1.295	1.30	9.8	3.9	36.2	69.8	144.8	265.8	2	531.6
AS-16-A LG. RADIO OBS ARRAY	1.614	1.30	9.8	4.7	45.2	97.4	114.6	266.2	1	266.2
OFS-1053 IR LBI	2.396	1.10	10.5	12.0	67.1	115.0	76.7	222.4	1	222.4
OFS-1054 CYDO IR TEDESC	4.420	1.60	14.7	22.1	125.6	327.0	1016.5	1567.5	1	1567.5
OFS-1055 MICROWAVE LBI	1.272	1.10	10.5	6.4	35.8	61.4	40.9	156.1	1	156.1
OFS-1072 AMB TLMP IR TEDESC	.511	1.55	14.7	2.6	21.5	29.7	99.2	169.2	1	169.2
OFS-1073 SUBMILLIMETER TEDESC	.511	1.55	10.5	2.6	14.3	17.4	77.7	124.0	1	124.0
AS-21-A IUE	.036	1.35	14.7	.1	1.5	2.2	7.3	27.2	1	27.2
AS-22-A RADIO EXPLORER	.354	1.25	9.8	1.1	9.9	9.7	34.7	66.6	1	66.6
AS-24-A IUE PHOTOMETRY	.036	1.35	14.7	.1	1.5	2.2	2.8	22.6	1	22.6

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number operating simultaneously, as shown in Table 2-1. The net score is multiplied by the maximum number of payloads to produce the total score in Table 5-2.

The data volumes and block weights of Table 5-2 were combined with the traffic model of Table 2-1, as described in Section 3.5, and the results are given in Table 5-3 for the data volume and Tables 5-4 to 5-9 for the block weights. The weight-number of payload products before summing over the payloads are given in these tables, and the discipline totals are shown at the bottom. Note that in Table 5-4 the number of Shuttle flights was used rather than the number of payloads operating.

The discipline totals are plotted in Figures 5-1 and 5-2 for data volume, the premission, real time operations, and preprocessing blocks. The other blocks exhibit essentially the same shapes as the preprocessing block. Note that the preprocessing (and unplotted block) profiles closely resemble the data volume profile. The close resemblance is partially based upon the relatively narrow spread of 0 to 3 in the payload weights and partially upon the averaging effect of regarding the total set of payloads as a whole. Suppose the payload weights had been 0, 10, 20, 30 instead of 0, 1, 2, 3. The resulting profiles would all have had exactly the same shape, and only their relative magnitudes would have changed (by a factor of 10).

From Figure 5-1, the year 1985 appears as a driver year because of the sudden jump in premission and real time operations requirements at that time. For premission requirements the highest peak occurs in 1988 just after a significant drop for two years; therefore that year is also regarded as a driver. Although a premission jump also occurs in 1980, it is still significantly below the others; therefore 1980 is ruled out. The highest peak in 1987 for real time operations differs relatively little from the surrounding years, therefore 1985 is judged to be the only driver for that block. These results are used in Section 5-8 to choose driver payloads.

TABLE 5-3 ANNUAL DATA VOLUME PROFILES FOR ASTRONOMY FREE FLIERS (UNITS OF 10^{12} BITS/YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
AS-01-A SPACE TELESCOPE			.219	.219	.219	.219	.219	.219	.219	.219	.219	.219	.219	.219
AS-02-A EXTRA COR. Lg EXPL.			.274	.274	.274	.274	.274	.274	.274	.274	.274	.274	.274	.274
AS-03-A COSM. BKGND. EXPL.		.128	.128	.256	.256	.383	.383	.511	.511	.511	.383	.383	.256	.256
AS-05-A ADV. RADIO ASTR. EXP			1.293	1.293	1.293	2.586	1.293	2.586	1.293	2.586	2.586	2.586	2.586	2.586
AS-16-A LG. RADIO OBS ARRAY								1.614	1.614	1.614	1.614	1.614	1.614	1.614
OFS-1053 IR LBI										2.396	2.396	2.396	2.396	2.396
OFS-1054 CIRCO IR TELESC								4.420	4.420	4.420	4.420	4.420	4.420	4.420
OFS-1055 MICROWAVE LBI				1.278	1.278	1.278	1.278	1.278	1.278	1.278	1.278	1.278	1.278	1.278
OFS-1072 AMB TEMP IR TELESC								.511	.511	.511	.511	.511	.511	.511
OFS-1073 SUBMILLIMETER TELESC							.511	.511	.511	.511	.511	.511	.511	.511
AS-21-A IUE		.219												
AS-22-A RADIO EXPLORER		.354	.354											
AS-24-A IUE PHOTOMETRY		.219	.219	.219										
DISCIPLINE TOTAL		.927	2.487	2.261	3.320	4.740	3.958	11.924	10.631	14.320	14.192	14.192	14.064	14.064

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5-10

TABLE 5-4 PREMISSION ANNUAL REQUIREMENTS PROFILES FOR ASTRONOMY FREE FLIERS (UNITS OF 10^{12} /YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
AS-01-A SPACE TELESCOPE			1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
AS-02-A EXTRA COR. LG. EXPL.			1.25		1.25		1.25		1.25		1.25		1.25	
AS-03-A COSM. BKGND. EXPL.	1.35			1.35		1.35		1.35		1.35	1.35	1.35	1.35	1.35
AS-05-A ADV. RADIO ASTR. EXP			1.30			1.30	1.30	1.30	1.30	1.30				
AS-16-A LG. RADIO OBS ARRAY								1.30		1.30		1.30		1.30
OFS-1053 IR LBI										1.10	1.10	1.10	1.10	1.10
OFS-1054 CYRO IR TELESC								1.60	1.60	1.60	1.60	1.60	1.60	1.60
OFS-1055 MICROWAVE LBI					1.10		1.10		1.10		1.10		1.10	
OFS-1072 AMB TEMP IR TELESC								1.55	1.55		1.55	1.55	1.55	
OFS-1073 SUBMILLIMETER TELESC							1.55	1.55			1.55	1.55	1.55	
AS-21-A IUE			1.35											
AS-22-A RADIO EXPLORER				1.35										
AS-24-A IUE PHOTOMETRY					1.35									
DISCIPLINE TOTAL	1.35	5.45	4.75	5.25	4.20	6.75	10.20	8.35	8.20	11.05	10.00	11.05	6.90	

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5-11

TABLE 5-5 REAL TIME OPERATIONS ANNUAL REQUIREMENTS PROFILES FOR ASTRONOMY FREE FLIERS (UNITS OF 10^{12} /YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
AS-01-A SPACE TELESCOPE			14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
AS-02-A EXTRA COR. L _α EXPL.			14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
AS-03-A COSM. BKGND. EXPL.		9.8	9.8	19.6	19.6	29.4	29.4	39.2	39.2	39.2	29.4	29.4	19.6	19.6
AS-05-A ADV. RADIO ASTR. EXP			9.8	9.8	9.8	19.6	9.8	19.6	9.7	19.6	19.6	19.6	19.6	19.6
AS-16-A LG. RADIO OBS ARRAY								9.8	9.8	9.8	9.8	9.8	9.7	9.7
OFS-1053 IR LBI										10.5	10.5	10.5	10.5	10.5
OFS-1054 CYRG IR TELESC								14.7	14.7	14.7	14.7	14.7	14.7	14.7
OFS-1055 MICROWAVE LBI					10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
OFS-1072 AMB TEMP IR TELESC								14.7	14.7	14.7	14.7	14.7	14.7	14.7
OFS-1073 SUBMILLIMETER TELESC								10.5	10.5	10.5	10.5	10.5	10.5	10.5
AS-21-A IUE		14.7												
AS-22-A RADIO EXPLORER		9.8	9.8											
AS-24-A IUE PHOTOMETRY		14.7	14.7	14.7										
DISCIPLINE TOTAL		49.0	72.8	72.8	68.6	88.2	88.9	147.1	137.7	151.2	148.4	148.4	138.6	138.6

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TABLE 5-6 REAL TIME DATA HANDLING ANNUAL REQUIREMENTS PROFILES FOR ASTRONOMY FREE FLIERS (UNITS OF 10^{12} /YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
AS-01-A SPACE TELESCOPE			1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
AS-02-A EXTRA COR. Lg EXPL.			.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8
AS-03-A COSM. BKGND. EXPL.		.7	.7	1.4	1.4	2.1	2.1	2.8	2.8	2.8	2.1	2.1	1.4	1.4
AS-05-A ADV. RADIO ASTR. EXP			3.9	3.9	3.9	7.8	3.9	7.8	3.9	7.8	7.8	7.8	7.8	7.8
AS-16-A LG. RADIO OBS ARRAY								4.9	4.9	4.9	4.9	4.9	4.9	4.9
OFS-1053 IR LBI										12.0	12.0	12.0	12.0	12.0
OFS-1054 CYRO IR TELESC								22.1	22.1	22.1	22.1	22.1	22.1	22.1
OFS-1055 MICROWAVE LBI					6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
OFS-1072 AMB TEMP IR TELESC								2.6	2.6	2.6	2.6	2.6	2.6	2.6
OFS-1073 SUBMILLIMETER TELESC							2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
AS-21-A IUE		.1												
AS-22-A RADIO EXPLORER		1.1	1.1											
AS-24-A IUE PHOTOMETRY		.1	.1	.1										
DISCIPLINE TOTAL		2.0	7.7	7.3	13.6	18.2	16.9	51.1	47.2	63.1	62.4	62.4	61.7	61.7

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TABLE 5-7 QUICK LOOK ANNUAL REQUIREMENTS PROFILES FOR ASTRONOMY FREE FLIERS (UNITS OF 10^{12} /YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
AS-01-A SPACE TELESCOPE			9.2	9.2	9.2	7.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
AS-02-A EXTRA COR. L _a EXPL.			7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
AS-03-A COSM. BKGND. EXPL.		3.6	3.6	7.2	7.2	10.8	10.8	14.4	14.4	14.4	14.4	10.8	7.2	7.2
AS-05-A ADV. RADIO ASTR. EXP			36.2	36.2	36.2	72.4	36.2	72.4	36.2	72.4	72.4	72.4	72.4	72.4
AS-16-A L.G. RADIO OBS ARRAY								45.2	45.2	45.2	45.2	45.2	45.2	45.2
OFS-1053 IR LE										67.1	67.1	67.1	67.1	67.1
OFS-1054 CYRO IR TELESC								185.6	185.6	185.6	185.6	185.6	185.6	185.6
OFS-1055 MICROWAVE LBI					35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8
OFS-1072 AMB TEMP IR TELESC								21.5	21.5	21.5	21.5	21.5	21.5	21.5
OFS-1073 SUBMILLIMETER TELESC							14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
AS-21-A IUE		1.5												
AS-22-A RADIO EXPLORER		9.9	9.9											
AS-24-A IUE PHOTOMETRY		1.5	1.5	1.5										
DISCIPLINE TOTAL		16.5	67.1	61.8	96.1	135.9	114.0	406.1	369.9	473.2	467.6	469.6	466.0	466.0

TABLE 5-8 PREPROCESSING ANNUAL REQUIREMENTS PROFILES FOR ASTRONOMY FREE FLIERS (UNITS OF 10^{12} /YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
AS-01-A SPACE TELESCOPE			13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
AS-02-A EXTRA COR. La EXPL.			14.2	14.8	14.8	14.2	14.8	14.8	14.9	14.8	14.8	14.2	14.8	14.2
AS-03-A COSM. BKGND. EXPL.	4.5	4.3	8.6	8.6	12.9	12.9	17.2	17.2	17.2	17.2	12.9	12.9	8.6	8.6
AS-05-A ADV. RADIO ASTR. EXP			57.7	69.8	69.8	139.6	69.8	139.6	69.8	139.6	139.6	139.6	139.6	139.5
AS-16-A LG. RADIO OBS ARRAY								90.4	90.4	90.4	90.4	90.4	90.4	90.4
OFS-1053 IR LBI										115.0	115.0	115.0	115.0	115.0
OFS-1054 CYRO IR TELESC								327.0	327.0	327.0	327.0	327.0	327.0	327.0
OFS-1055 MICROWAVE LBI					61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4
OFS-1072 AMB TEMP IR TELESC								29.7	29.7	29.7	29.7	29.7	29.7	29.7
OFS-1073 SUBMILLIMETER TELESC							17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4
AS-21-A IUE	2.2													
AS-22-A RADIO EXPLORER	9.9	9.9												
AS-24-A IUE PHOTOMETRY	2.2	2.2	2.2											
DISCIPLINE TOTAL	12.6	114.1	108.5	167.7	241.8	129.4	710.6	640.8	825.6	821.3	821.3	817.0	817.0	

TABLE 5-9 ANALYSIS ANNUAL REQUIREMENTS PROFILES FOR ASTRONOMY FREE FLIERS (UNITS OF 10^{12} /YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
AS-01-A SPACE TELESCOPE			52.7	52.7	52.7	52.7	52.7	52.7	52.7	52.7	52.7	52.7	52.7	52.7
AS-02-A FYTRA COR. Lg EXPL.			56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4	56.4
AS-03-A COSM. BKGND. EXPL.		12.2	12.2	36.4	36.4	54.6	54.6	72.8	72.8	72.8	54.6	54.6	36.4	36.4
AS-05-A ADV. RADIO ASTR. EXP			144.8	144.8	144.8	229.6	144.8	229.6	144.8	229.6	229.6	229.6	229.6	229.6
AS-16-A LG. RADIO OBS ARRAY								114.6	114.6	114.6	114.6	114.6	114.6	114.6
OFS-1053 IR LBI										76.7	76.7	76.7	76.7	76.7
OFS-1054 CYRG IR TELESC								1016.5	1016.5	1016.5	1016.5	1016.5	1016.5	1016.5
OFS-1055 MICROWAVE LBI					40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9
OFS-1072 AMR TEMP IR TELESC								99.2	99.2	99.2	99.2	99.2	99.2	99.2
OFS-1073 SUBMILLIMETER TELESC							77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
AS-21-A IUE		7.3												
AS-22-A RADIO EXPLORER		34.7	34.7											
AS-24-A IUE PHOTOMETRY		2.2	2.8	2.8										
DISCIPLINE TOTAL		63.0	315.6	299.1	337.2	500.2	433.1	1226.4	1681.5	1903.1	1884.9	1884.9	1866.7	1866.7

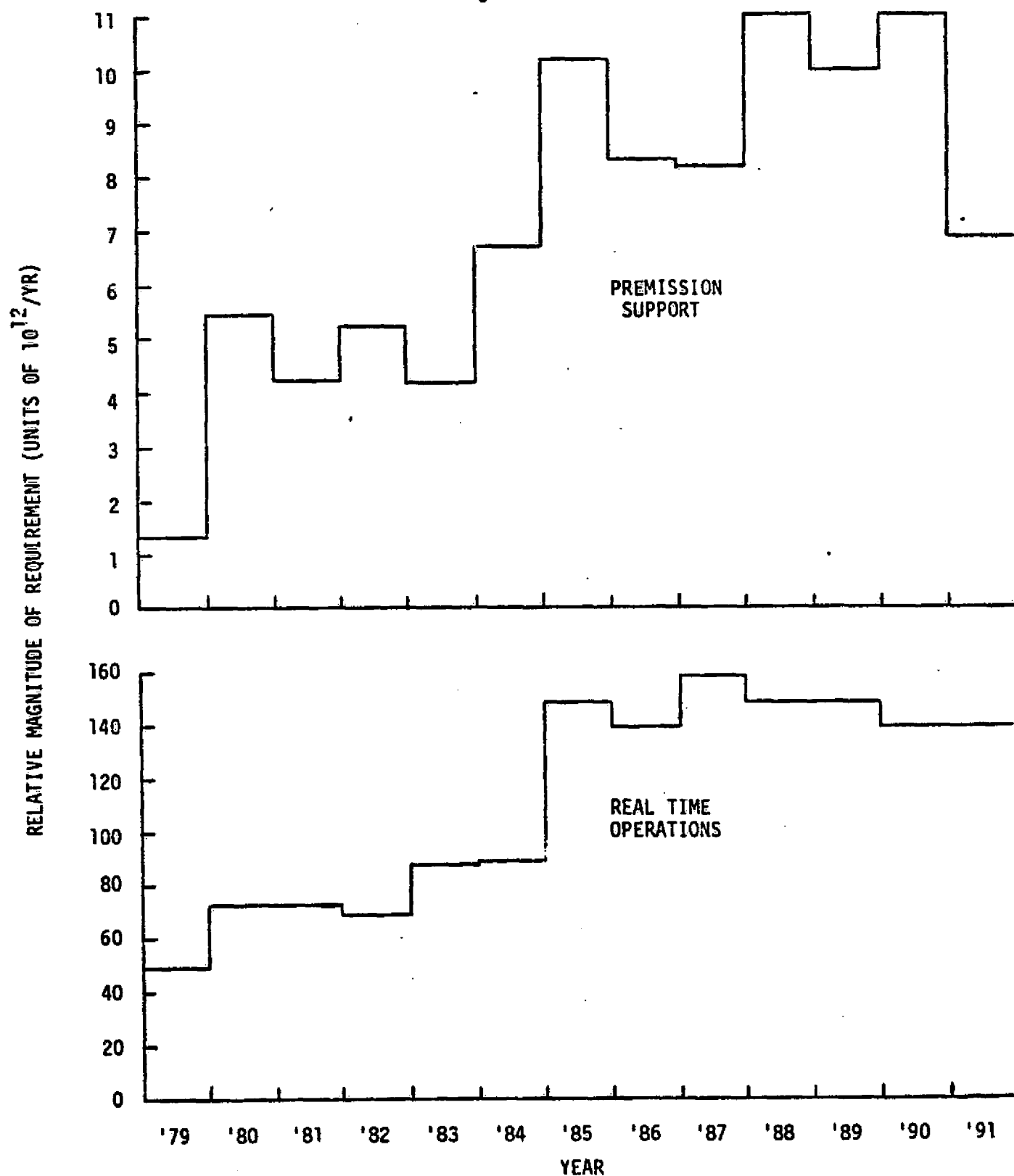


FIGURE 5-1 PREMISSION AND REAL TIME OPERATIONS ANNUAL REQUIREMENTS FOR ASTRONOMY FREE FLIERS

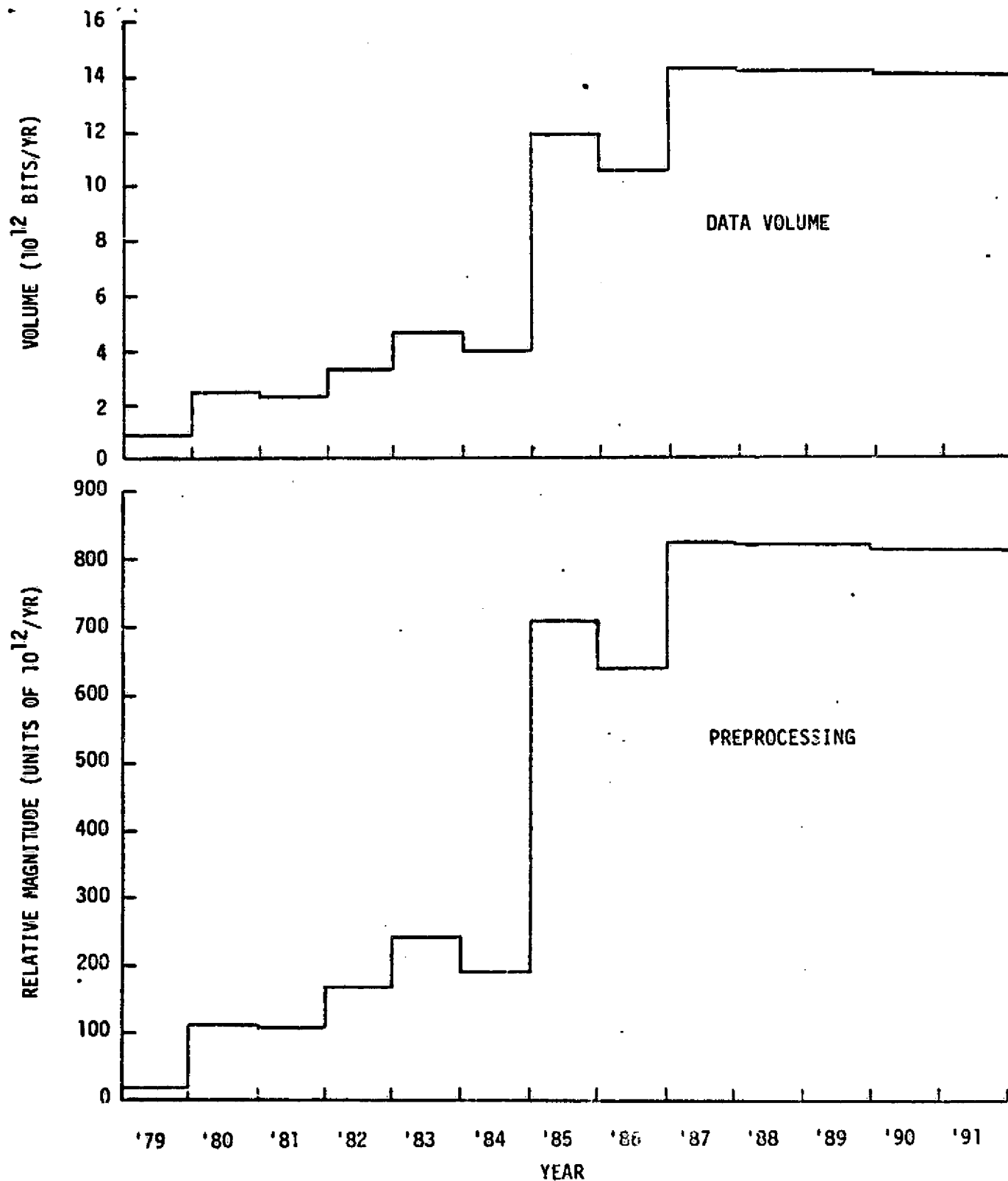


FIGURE 5-2 ANNUAL DATA VOLUME AND PREPROCESSING ANNUAL REQUIREMENTS FOR ASTRONOMY FREE FLIERS

5.4 High Energy Astrophysics Free Flier Weights

In this section the payload weights are selected and used with the data volumes selected in Section 5.2 to determine the block weights and finally the operations requirements for the High Energy Astrophysics free fliers.

The payload weights are shown in Table 5-10. The premission weights for most payloads are about average. The heaviest weights are in the mission planning, sensor design, and sensor calibration areas. The primary reason for this is that many of the instruments have not been used on the ground resulting in less than average experience with design and calibration problems.

The real time operation weights are low in value for most payloads. Except for the x-ray instruments, pointing and guiding are minor problems since the IFOV is rather large for the gamma-ray and cosmic-ray instruments.

Similarly, the quick look weights are also low. The combination of large IFOV and low event rates result in many of the instruments operating in a survey mode in contrast to one in which detailed data is quickly acquired and quick decisions are necessary before the next step can be taken.

The preprocessing weights are moderate to light. The greatest amount of preprocessing is likely to be in the geometric correction and radiometric correction areas.

The analysis weights are low in value for most payloads. The processes most consistently given heavy weights are spectrum analysis and abundance and structure determination.

The process block weights are shown in Table 5-11. Because of the heavy process weights in the analysis block as given in Table 5-10, this block is the

TABLE 5-10 PAYLOAD WEIGHT MATRIX FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS

PREMISSION	REAL TIME OPS	R. T. DATA HANDL	Q.L.	PREPROCESSING				ANALYSIS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
Mission Planning	Sensor Design Supt	Experiment Control	Pre-trans; LOS Guid	Demux; etc.	Quick Look	Image Digitization	Geom Corr'n / Reg	Image Editing	Filtering; etc.	Fourier Analysis	Arch. / Distrib	Classification	Spectrum Anal	Temporal Anal	Abund	Morphology / Struct	Orbit Determ.	Polarization	Ang. Diam.	Soil Stratigraphy	Miscellaneous																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

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5-27

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most heavily weighted for all payloads. Preprocessing is the next most heavily weighted block. In the third column from the right a score is given to each payload according to the selected weights. It is evident that the Cosmic Ray Laboratory (HE - 12 - A) has a much greater requirement than that of all the other payloads combined. The last column gives a score taking into account the number of payloads placed in orbit, but the result is the same as for the first score.

The total data volume annual requirement profile is shown in Table 5-12. In the last line of the table the volumes are summed for all payloads for each year. This data is plotted in Figure 5-4. Note that the driver year is 1987 during which the volume jumps from $1.77E12$ to $11.4E12$.

The premission annual requirement profile is tabulated in Table 5-13 and plotted in Figure 5-3. The driver year is 1980 during which the requirement increases four-fold.

The real time operations annual requirement profile is tabulated in Table 5-14 and plotted in Figure 5-3. The driver year is 1986 since the requirement peaks during this year.

The annual requirement profiles for real time data handling, quick look, preprocessing, and analysis are given in Tables 5-15 through 5-18. The preprocessing requirement is plotted in Figure 5-4 and is typical of the four functions. The driver year is 1987 during which a very significant increase in the processing requirements occurs. Also 1980 is a driver for premission requirements, and 1985 is the driver year for real time operations.

TABLE 5-12 DATA VOLUME ANNUAL PROFILE FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS (1E12 BITS/YR)

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
HE-01-A LG. X-RAY TELE. FAC.									0.26	0.26	0.26	0.26	0.26	
HE-03-A EXTEND'D X-RAY SUR.					0.20	0.20	0.20	0.20						
HE-05-A HI. LAT. COS.-RAY SUR.														3.7E-5
HE-07-A SM. HI. ENER. SAT.	0.06	0.06	0.06	0.06	0.13	0.13	0.13	0.13	0.13	0.13	0.20	0.20	0.20	0.20
HE-08-A OBS. A-GAMMA RAY									0.32	0.32	0.32	0.32		
HE-09-A OBS. B-MAG. SPEC.		0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
HE-10-A OBS. C-NUC.										0.25	0.25	0.25	0.25	0.25
HE-11-A OBS. D-X-RAY					0.10	0.10	0.10	0.10						
HE-12-A COSMIC RAY LAB.										9.5	9.5	9.5	9.5	9.5
HE-23-A HI. ENER. ASTRO.OBS.C	0.1													
TOTAL		0.16	1.02	1.09	1.29	1.39	1.39	1.39	1.77	11.4	11.5	11.5	11.2	10.9

TABLE 5-13 PREMISSION ANNUAL REQUIREMENTS PROFILE FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
HE-01-A LG. X-RAY TELE. FAC.									1.9		1.9		1.9	1.9
HE-03-A EXTEND'D X-RAY SUR.					1.3	1.3		1.3	1.3					
HE-05-A HI. LAT. COS.-RAY SUR.														1.4
HE-07-A SM. HI. ENER. SAT.				1.2			2.3				1.2	2.3	2.3	2.3
HE-08-A OBS. A-GAMMA RAY									1.3	1.3		1.3	1.3	
HE-09-A OBS. B-MAG. SPEC.			4.8											
HE-10-A OBS. C-NUC.										1.6		1.6	.	.
HE-11-A OBS. D-X-RAY						1.9	1.9	1.9		1.9				
HE-12-A COSMIC RAY LAB.										1.6	1.6	1.6	1.6	1.6
HE-23-A HI. ENER. ASTRO.OBS.C		1.6	1.6											
TOTAL		1.6	6.4	1.2	1.3	3.2	4.2	3.2	4.5	6.4	4.7	6.8	7.1	7.2

TABLE 5-14 REAL TIME OPERATIONS ANNUAL REQUIREMENTS PROFILE FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS

5-25

TABLE 5-15 REAL TIME DATA HANDLING ANNUAL REQUIREMENTS PROFILE FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
HE-01-A L.G. X-RAY TELE. FAC.									1.6	1.6	1.6	1.6	1.6	
HE-03-A EXTEND'D X-RAY SUR.				1.2	1.2	1.2	1.2							
HE-05-A HI. LAT. COS.-RAY SUR.														3E-4
HE-07-A SM. HI. ENER. SAT.	0.32	0.32	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.98	0.98	0.98	0.98
HE-08-A OBS. A-GAMMA RAY									1.9	1.9	1.9	1.9		
HE-09-A OBS. B-MAG. SPEC.		5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
HE-10-A OBS. C- NUC.										1.5	1.5	1.5	1.5	1.5
HE-11-A OBS. D- X-RAY						0.59	0.59	0.59	0.59					
HE-12-A COSMIC RAY LAB.										57	57	57	57	57
HE-23-A HI. ENER. ASTRO.OBS.C	0.6													
TOTAL		0.92	6.1	6.4	7.6	8.2	8.2	8.2	11	68	69	69	67	65

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TABLE 5-16 QUICK LOOK ANNUAL REQUIREMENTS PROFILE FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
HE-01-A LG. X-RAY TELE. FAC.									11	11	11	11	11	
HE-03-A EXTEND'D X-RAY SUR.					5.6	5.6	5.6	5.6						
HE-05-A HI. LAT. COS.-RAY SUR.														5E-4
HE-07-A SM. HI. ENER. SAT.	1.8	1.8	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	5.5	5.5	5.5	5.5
HE-08-A OBS. A-GAMMA RAY									9.0	9.0	9.0	9.0		
HE-09-A OBS. B-MAG. SPEC.		13	13	13	13	13	13	13	13	13	13	13	13	13
HE-10-A OBS. C-NUC.										3.5	3.5	3.5	3.5	3.5
HE-11-A OBS. D-X-RAY						4.1	4.1	4.1	4.1					
HE-12-A COSMIC RAY LAB.										133	133	133	133	133
HE-23-A HI. ENER. ASTRO.OBS.C	1.4													
TOTAL	3.2	15	17	23	27	27	27	27	41	173	175	175	166	155

TABLE 5-12 PREPROCESSING ANNUAL REQUIREMENTS PROFILES FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
HE-01-A LG. X-RAY TELE. FAC.									14	14	14	14	14	
HE-03-A EXTEND'D X-RAY SUR.				10	10	10	10							
HE-05-A HI. LAT. COS.-RAY SUR.														20-4
HE-07-A SM. HI. ENER. SAT.	3.2	3.2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	9.8	9.8	9.8	9.8
HE-08-A OBS. A-GAMMA RAY									12	12	12	12		
HE-09-A OBS. B-MAG. SPEC.		31	31	31	31	31	31	31	31	31	31	31	31	31
HE-10-A OBS. C-NUC.										9.5	9.5	9.5	9.5	9.5
HE-11-A OBS. D-X-RAY						5.1	5.1	5.1	5.1					
HE-12-A COSMIC RAY LAB.										190	190	190	190	190
HE-23-A HI. ENER. ASTRO.OBS.C	2													
TOTAL	52	34	37	47	52	52	52	52	68	262	265	265	254	240

TABLE 5-18 ANALYSIS ANNUAL REQUIREMENTS PROFILES FOR HIGH ENERGY ASTROPHYSICS FREE FLIERS

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
HE-01-A LG. X-RAY TELE. FAC.									21	21	21	21	21	
HE-03-A EXTEND'D X-RAY SUR.				5.1	5.1	5.1	5.1							
HE-05-A HI. LAT. COS.-RAY SUR.														6E-3
HE-07-A SM. HI. ENER. SAT.	3.5	3.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	11	11	11	11
HE-08-A OBS. A-GAMMA RAY									51	51	51	51		
HE-09-A OBS. B-HAG. SPEC.		117	117	117	117	117	117	117	117	117	117	117	117	117
HE-10-A OBS. C-NUC.										31	31	31	31	31
HE-11-A OBS. D-X RAY						13	13	13	13					
HE-12-A COSMIC RAY LAB.										1160	1160	1160	1160	1160
HE-23-A HI. ENER. ASTRO.OBS.C	12													
TOTAL	16	121	124	129	142	142	142	208	1386	1390	1390	1390	1339	1318

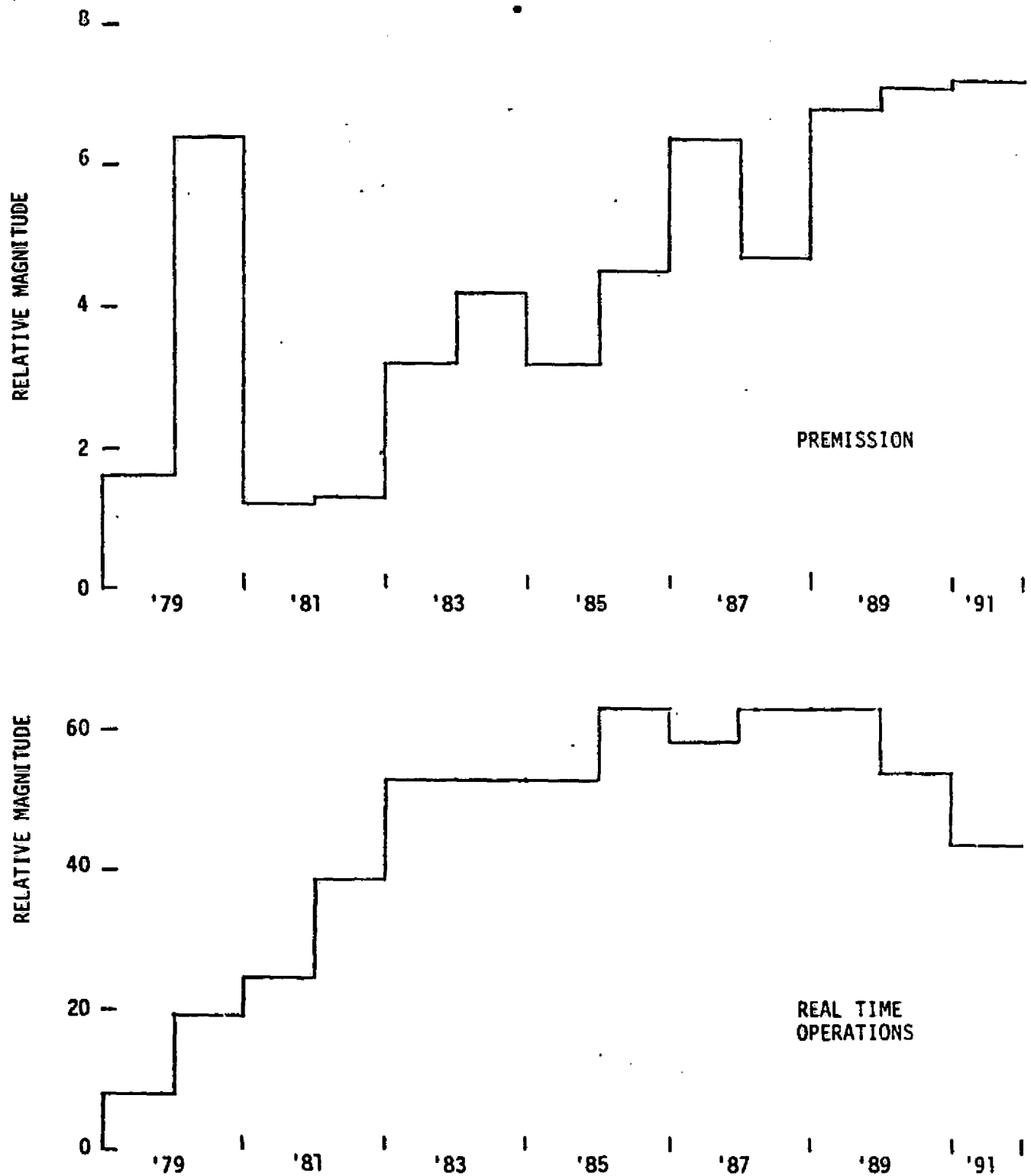


FIGURE 5-3 PREMISSION AND REAL TIME OPERATIONS
REQUIREMENTS PROFILES

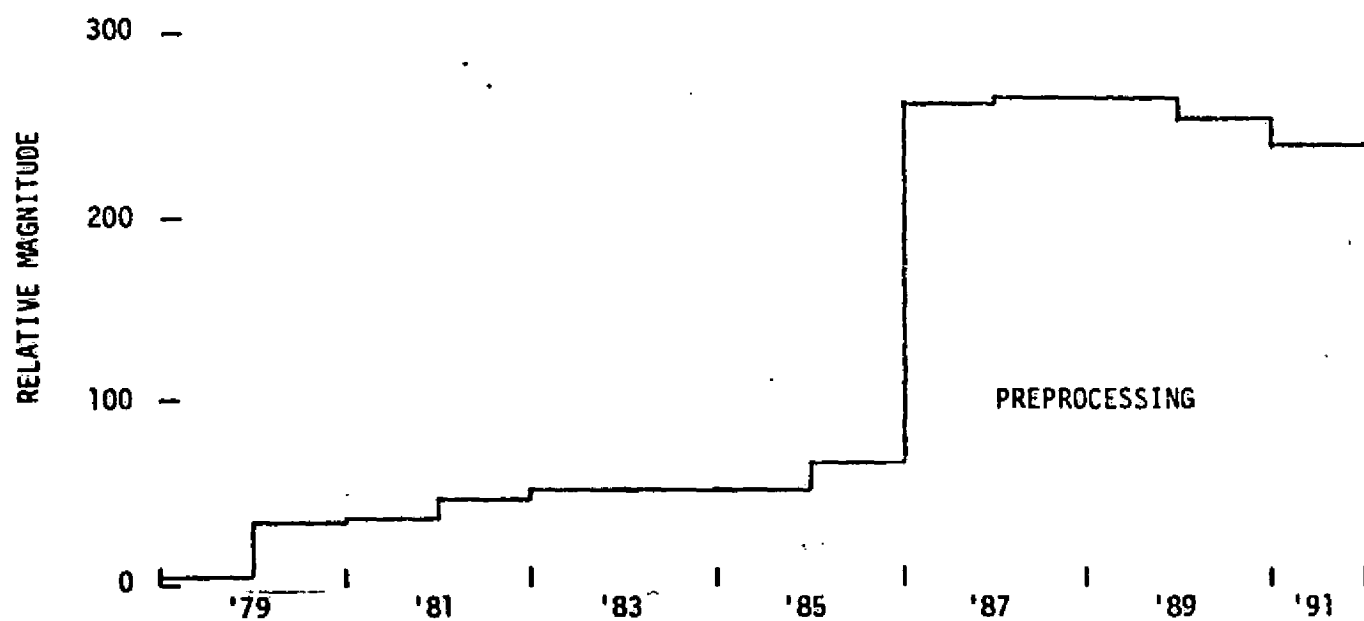
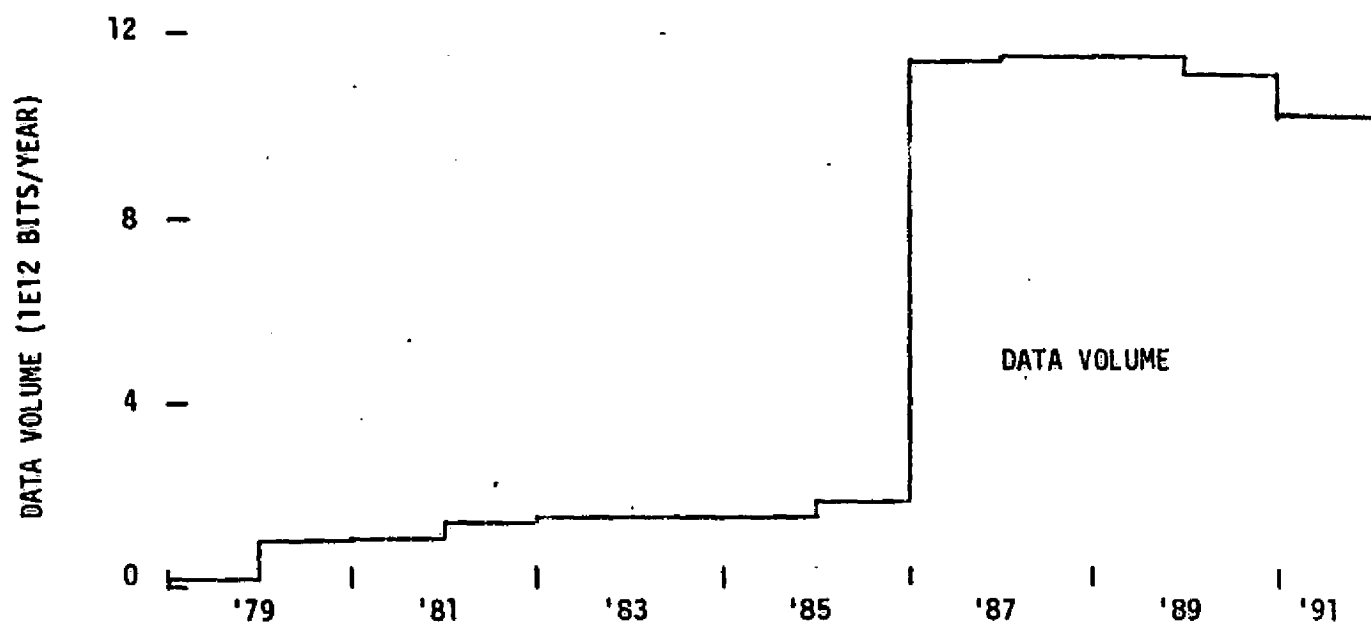


FIGURE 5-4 DATA VOLUME AND PREPROCESSING
REQUIREMENTS PROFILES

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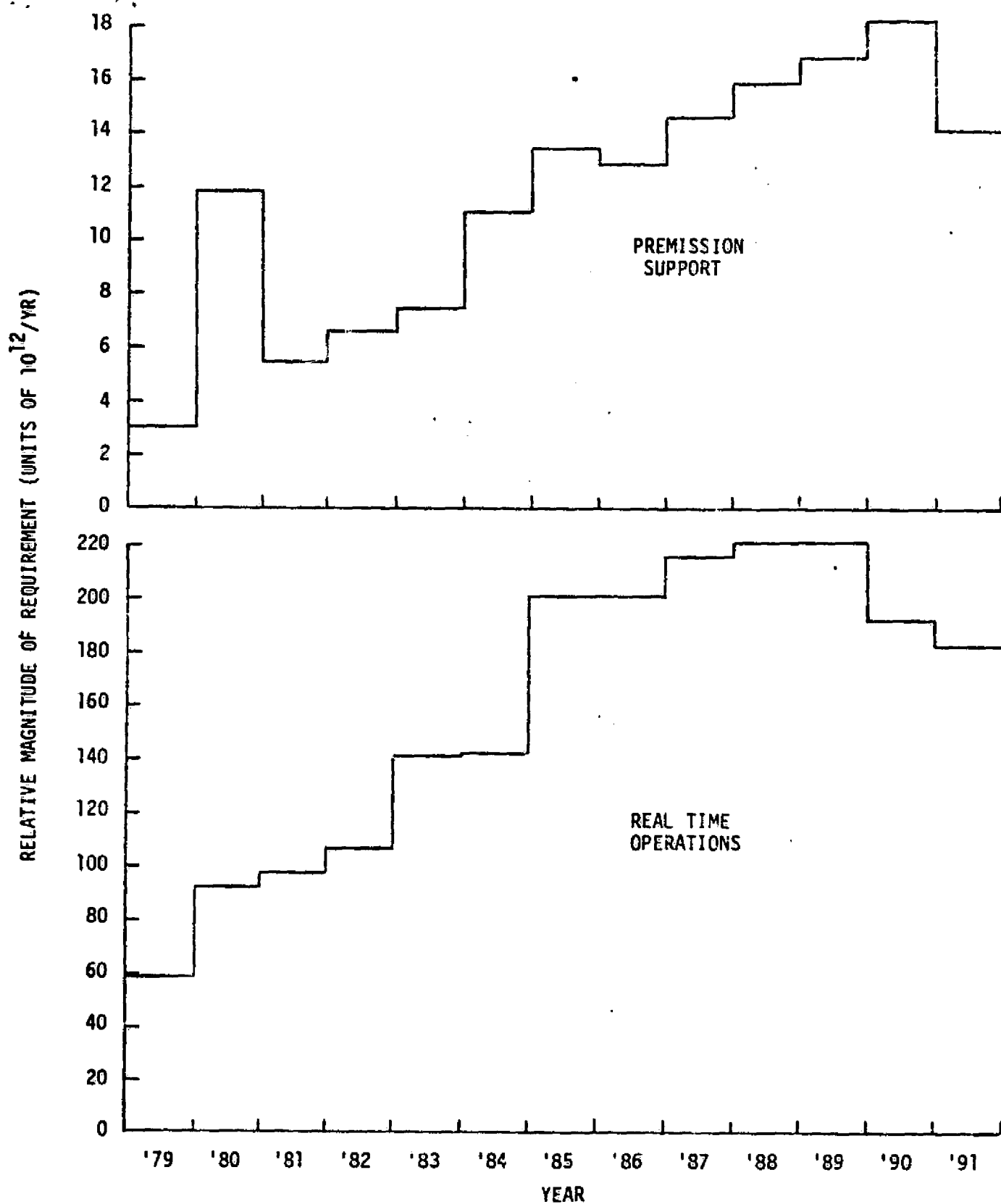


FIGURE 5-5. PREMISSION AND REAL TIME OPERATIONS ANNUAL REQUIREMENTS FOR COMBINED ASTRONOMY AND HIGH ENERGY ASTROPHYSICS FREE FLIERS

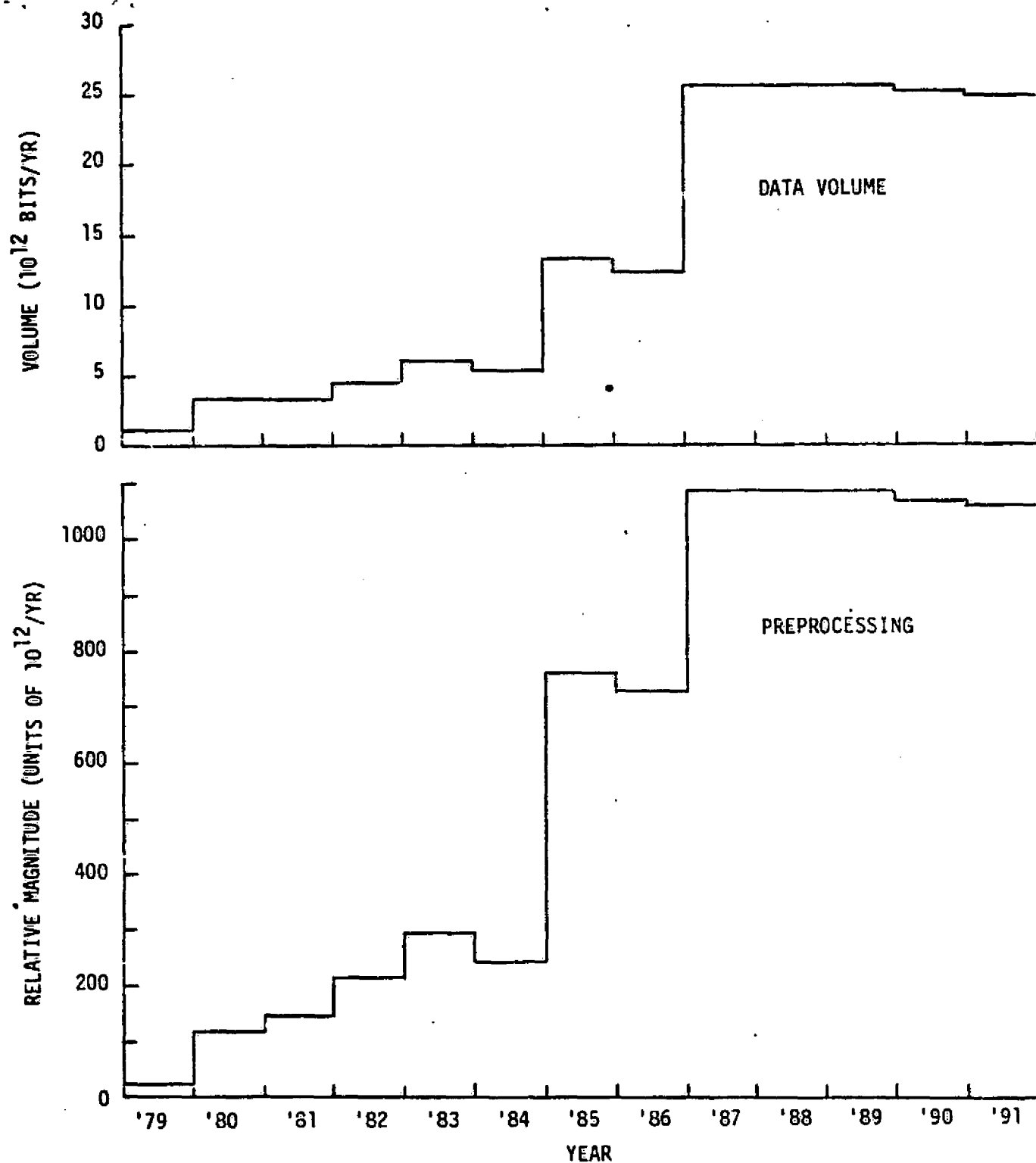


FIGURE 5-6 ANNUAL DATA VOLUME AND PREPROCESSING ANNUAL REQUIREMENT FOR COMBINED ASTRONOMY AND HIGH ENERGY ASTROPHYSICS FREE FLIERS

5.5 Combined Astronomy and High Energy Astrophysics Free Flier Weights

Astronomy and high energy astrophysics are so closely related that the operations and data processing for their payloads may be performed at the same centers. Thus, it is appropriate to investigate the impacts of considering the two disciplines together. The combined discipline data volumes and weights, obtained by adding the discipline totals of Tables 5-12 to 5-18 to those of Tables 5-3 to 5-9, respectively, are summarized in Table 5-19. The totals are plotted in Figures 5-5 and 5-6. Again, the data volume dependent processing blocks are adequately represented by preprocessing.

The years 1980 and 1990 are judged to be the driver years for premission processing, the former because it is an early peak and the latter because it is the highest peak. The first year reflects the premission requirements mainly of high energy astrophysics. The real time operations driver year appears to be 1989, corresponding to the highest peak, although the jump in 1985 makes that year a possible candidate. It appears from Figure 5.5, however, that a system buildup to accommodate 1989 would probably automatically take care of 1985; therefore the latter year is ruled out as a driver. The other processing functions (see Figure 5-6) indicate 1987 is the driver year, as was noted for each of the disciplines separately.

5.6 Astronomy and High Energy Astrophysics Sortie Data Volumes

The sortie data volumes were derived from SPDA data, from Facility Definition Team (FDT) reports, and from the Red Books (Reference 8). The data volumes are summarized payload-by-payload below. Unless otherwise specified, all sortie payloads are assumed to be carried in a 30 day mission having 16 orbits per day and 29 days of useful observing time. Two 30 day missions per year are assumed. In some cases separate preprocessing and analysis volumes are determined, as described in Section 5.2.

- o Spacelab Ultraviolet - Optical Telescope (SUOT) Direct imaging camera (DIC): .5 degree diameter field of view (FOV)/.1375 arcsec instantaneous FOV (IFOV, or pixel) (corresponding to 10 μ m in focal plane at f/15 telescope - FDT interim report) = 1.346 E8 pixels/circular frame (after scanning and digitizing film) x 2.5 frames/orbit average (Gull - 2 or 3) = 3.365E8 bits/orbit. Echelle spectrograph (operates concurrently with DIC): 1E5 resolving power (SPDA) gives .25E8 pixels/square frame (Reference 5) x 120/160 fraction containing usable spectrum (Reference 5 - trapezoidal frame envelope for spectrum) = .1875E8 pixels/trapezoidal frame x 2 frames/orbit assumed = .375E8 pixels/orbit. Add DIC and echelle volumes and 5% for calstrios (assumed) x 12 bits/pixel = 2.18E12 bits/mission or 4.36E12 bits/yr.
- o Schmidt Camera/Spectrograph 11 degree diameter FOV/20 arcsec IFOV (data from Red Books) = 3.08E6 pixels/circular frame x 2 frames/orbit (20 minute exposure each - Red Books) x 12 bits/pixel = .0343E12 bits/mission or .068E12 bits/yr.
- o Schwartzschild Camera .2 rad diameter FOV/12 arcsec IFOV (data from Red Books) = .0928E8 pixels/circular frame x 2 frames/orbit (20 minute exposure each - Red Books) x 12 bits/pixel = .103E12 bits/mission or .206E12 bits/yr.
- o Small IR Cryogenic Telescope 1E7 bits/day (Red Books) = .29E8 bits/mission or .58E8 bits/yr.
- o Extreme Ultraviolet (EUV) Imaging Telescope Analysis data volume (i.e. after significant compression during preprocessing): about 1000 pixels/image (Red Books - consistent with 10 cm square RANICON detector, 100 cm focal length yielding .1 rad FOV and 10 arcmin IFOV) x 1 frame/orbit average (Red Books - 1 min to 5 hr exposure) x 12 bits/pixel = 6E7 bits/mission or 12E7 bits/yr. Preprocessing data volume (for real time, quick look and preprocessing): 20 kbps (Red Books) x 80 min exposure/orbit (assumed) = .0445E12 bits/mission or .089E12 bits/yr.
- o EUV Spectrometer Analysis data volume: 24 channels/frame width (assuming 75mm frame size and same channel density as for EUV Imaging Telescope which has 32 channels over 100mm) x 5 pixels/channel (assuming slit width/length ratio of 5:1) x 15 frames/orbit

(assuming 6 sec exposure average/frame from 2 sec to 10 sec/frame for sweep of 1 - 50/sec - Red Books) x 12 bits/pixel = 1E7 bits/mission or 2E7 bits/yr. Preprocessing data volume: 40 kbps x 5 min/orbit + 10 kbps x 85 min/orbit (5 min on aurorae - Red Books) = .63E8 bits/orbit = .029E12 bits/mission or .058E12 bits/yr

- o UV Photometer Analysis data volume: 12 detectors (Red Books) x 2 settings/orbit (20 min/setting - Red Books) x 16 bits/word = .19E6 bits/mission or .38E6 bits/yr. Preprocessing data volume: 2.7E7 bits/day (Red Books) = 7.83E8 bits/mission or 15.6E8 bits/yr.
- o Microchannel Spectrometer Analysis data volume: future projected spectral bandwidth (Red Book) 900A/1A resolution = 900 pixels/exposure x 3 exposures/orbit (assuming 20 min exposure average - 10 sec to 1 hr - Red Books) x 12 bits/pixel = 1.5E7 bits/mission or 3E7 bits/yr. Preprocessing data volume: present data rate of 5E5 (Red Books) projected to 5E6 bps (based on expected 10-fold increase in sensitivity and electronic bandwidth - Red Books) x 60 min exposure/orbit (assumed) = 8.352E12 bits/mission or 16.704E12 bits/yr.
- o UV Polarimeter 1 kbps (Red Books) x 2/3 duty cycle/orbit (assumed) = .167E10 bits/mission or .334E10 bits/yr.
- o IUE Spectrograph Assume same rate as for free flying IUE = 1E8 bits/day = .29E10 bits/mission or .58E10 bits/yr.
- o Ambient Temperature IR Telescope 14.2E8 bits/day (SPDA - see free flier version in Section 5.1 for details) = .0412E12 bits/mission or .0824E12 bits/yr.
- o 30m IR LBI 65.6E8 bits/day (SPDA - see free flier version in Section 5.1 for details) = .19E12 bits/mission or .38E12 bits/yr.
- o Deep Sky Ultraviolet Survey Telescope (DUST) .087 rad diameter FOV(SPDA)/1 arcsec IFOV (assumed - corresponding to 7μ pixel on film, a reasonable size according to SUOT FDT report) = 2.53E8 pixels/circular image x 12 bits/pixel x 6 frames/orbit (SPDA - 2 exposures for each of 3 cameras) = 8.45E12 bits/mission or 16.90E12 bits/yr.
- o Spacelab IR Telescope Facility (SIRTF) 25 kbps (Melugin) x same exposure time/orbit as for free flying Cryogenically Cooled IR Telescope = 12.1E8 bits/day = .0351E12 bits/mission or .07E12 bits/yr.

- o Very Wide Field Galactic Camera 100° diameter FOV (60° to 100° - SPDA)/
 1 arcmin IFOV (assumed from SPDA pointing stability of 1 arcmin)
 = $.265E8$ pixels/circular frame x 2 frames/orbit (SPDA - 2 cameras,
 1 frame each) x 12 bits/pixel = $.295E12$ bits/mission or $.59E12$ bits/yr.

The high energy astrophysics sortie payloads were assumed to operate at a .5 duty cycle to allow for pointing, earth blockage, etc. A thirty day mission, of which 29 days may be used, was assumed, and two missions were assumed per year. The data rates were taken directly from the Red Books and multiplied by 43200 sec/half-day times 29 days/mission times 2 for the yearly volume. The resulting volumes are summarized in Table 5-23 in the next section.

5.7 Astronomy and High Energy Astrophysics Sortie Weights

The payload weights for astronomy and high energy astrophysics payloads are tabulated in Tables 5-20 and 5-21, respectively. The criteria established in Sections 5.1 and 5.2 were used to set the weights. The block summed weights and the net score, computed just as in Sections 5.3 and 5.4, are summarized in tables 5-22 and 5-23 for astronomy and high energy astrophysics, respectively.

The discipline weights for the sorties are obtained by summing the block weights over all payloads contained in a sortie flight, thereby requiring candidate flight cargo inventories. The Red Books define one such flight, a "typical" flight, (called "Group III") for astronomy and two such flights ("Payload A" and "Payload B", respectively) for high energy astrophysics. The Red Book "Group III" flight is described in Figure 5-7, and the high energy "Payloads A and B" are summarized in Table 5-24. An alternative to the astronomy flight is obtained by replacing the SUOT with a DUST. Although the mission analysis has not been performed on that configuration, it appears to be viable because the DUST dimensions compare with the SUOT. Three other astronomy sortie payloads are considered, but their size or usage require flying alone. The resulting five astronomy sortie flights are summarized in Table 5-25. It would

TABLE 5-20 PAYLOAD WEIGHT MATRIX FOR ASTRONOMY SORTIES

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PREMISSION	REAL TIME OPS	R.T. DATA HANDL	Q.L.	PREPROCESSING	ANALYSIS															FINAL PAGE IS POOR QUALITY									
Op System Devel Mission planning Sensor Training Sensor Design Experiment cal / test Pointing / LOS Guid Pre-trans: Control Demux: etc. Quick Look Image Digitization Radiometric Corr Geom Corr / Reg Filtering, etc. Fourier Analysis Arch. / Distrib. Spectrum Anal Temporal Anal Classification Morphology / Struct Orbit Determ. Polarization Ang. Diam. Soil Analysis Stratigraphy Miscellaneous	6	6	2	1	2	6	1	1	2	14	8	10	2	6	4	12	2	30	8		8	30	15	8	6	3	4	15	6
(Vol 2, p 3.17) Camera/Spectr. (Vol 2, p 3.37) Schmidt Camera (p 3.25) Cryo. Telesc. (p 3.27) Telesc. (p 3.30) Spectrometer (p 3.33) Spectrometer (p 3.42) Channel Spectr. (p 3.43) Spectrometer (p 3.47) Spectrograph (p. IR Telesc. SIRTF (p. 3.48) SIRTF Field Gal. Cam	2	2	3	1	3	3	3	1	2	2	2	2	2	2	2	0	1	2	3	2	3	3	3	1	1	0	0	0	0
	2	1	1	0	2	2	2	1	2	1	2	2	1	1	1	0	1	2	2	0	1	1	0	0	0	0	0	0	0
	2	1	1	1	2	2	2	1	2	1	2	2	3	1	1	0	1	2	0	0	1	3	0	1	0	0	0	0	
	2	1	2	1	2	2	3	2	2	2	2	0	1	3	2	1	0	1	2	2	0	2	2	0	0	0	0	0	
	2	1	1	1	2	2	3	2	2	2	2	0	1	1	1	1	0	1	1	0	0	1	3	0	0	0	0	0	
	2	1	1	1	2	1	1	2	2	2	2	0	1	1	2	1	0	1	1	2	1	2	0	0	0	0	0	0	
	2	1	1	0	1	3	1	1	2	2	2	0	0	3	0	0	0	2	1	0	1	0	0	0	0	0	0	0	
	2	1	1	0	2	3	2	2	2	2	2	0	1	1	1	0	0	1	1	2	1	2	0	0	0	0	0	0	
	2	1	1	0	2	3	1	1	2	2	2	0	0	2	0	0	0	1	1	0	1	0	0	0	3	0	0	0	
	2	1	1	1	2	3	3	1	2	3	3	0	3	3	2	1	0	2	1	3	2	3	1	3	0	0	0	0	
	2	2	3	1	3	3	3	1	2	3	3	0	2	3	2	1	1	2	1	2	3	2	3	2	0	1	0	0	
	2	1	2	2	2	3	3	1	2	2	2	0	1	2	0	2	2	1	0	0	0	0	1	1	0	3	0	0	
	2	1	1	1	3	3	2	1	2	1	2	2	2	1	1	0	2	2	2	0	2	3	0	0	0	0	0	0	
	2	2	3	2	3	3	3	1	2	3	3	0	2	3	2	2	2	2	1	3	2	3	3	2	1	1	0	0	
	2	1	1	1	2	3	2	1	2	1	2	2	2	2	1	0	1	2	0	0	1	3	0	0	0	0	0	0	

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PREMISSION	REAL TIME OPS	R.T. DATA HANDL	Q.L.	PREPROCESSING	ANALYSIS																								
Op System Devel	Sensor Training	Sensor cal / test	Experiment Pointing / LOS Supt	Demux; etc. Pre-trans; transm	Quick Look	Image Digitization	Geom Corr / Reg	Radiometric Corr	Image Editing	Fourier Analysis	Arch. / Distrib.	Filtering, etc.	Spectrum Anal	Temporal Anal	Abund	Morphology / Struct	Orbit Determ.	Polarization	Ang. Diam.	Soil Stratigraph	Miscellaneous								
PAYLOAD	PROCESS WEIGHT	6	6	2	1	2	6	1	1	2	14	8	10	2	6	4	12	2	30	8	8	30	15	8	6	3	4	15	6
SX-3/GII	Hi Energy Sources	2	1	1	1	1	2	1	2	2	2	1	1	2	2	1	1	1	1	2	2	2	1	1	0	0	0	0	0
SX-7/GIII	Polarim/Bragg Spectr.	2	1	1	1	2	2	1	2	2	2	1	1	2	1	1	0	1	1	2	1	2	0	0	2	0	0	0	0
SG8 & 9/GIV	Hi En. Gamma Rays	2	1	2	2	2	2	2	2	2	2	1	1	2	2	0	1	1	1	2	2	2	2	2	0	1	0	0	0
SG5 & 8/GV	Low En. Gam. Ray & Nuc.	1	1	1	2	2	2	1	2	2	2	0	0	2	2	1	0	1	2	2	1	2	0	0	0	0	0	0	0
SC1 & 4/GVII	Trans. Rad. Spectr.	2	2	1	2	2	1	1	2	2	2	1	1	1	1	0	0	1	1	2	0	2	0	0	0	0	0	0	0
SX1/GI	Lg Area X-Ray w/Concentr.	2	1	2	1	2	2	1	2	2	2	1	1	1	1	0	1	1	0	0	2	0	2	2	0	0	0	0	0
SC1 & 4/GVI	Ioniz. Spectrometer	2	1	1	1	1	1	1	2	2	1	0	1	2	1	1	0	1	1	2	1	2	0	0	0	0	0	0	0
SC4/GVIII	Negatron/Position	2	1	1	2	2	1	1	2	2	2	1	1	1	1	0	0	1	1	2	1	2	0	0	0	0	0	0	0
SC2/GIX	Isotope Abundance	2	2	1	2	2	1	1	2	2	2	1	1	2	1	0	0	1	1	1	0	2	0	0	0	0	0	0	0

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TABLE 5-22 DATA VOLUMES, BLOCK WEIGHTS, AND SCORES FOR ASTRONOMY SORTIES

PAYLOAD	Data Volume (10^{12} bits/yr)	Pre-mission	Real Time Ops	Real Time Data Handling	Quick Look	Pre-Processing	Analysis	Net Score Per Payload
AS-04-S SWOT	2.18	1.85	14.7	10.9	61.0	135.2	584.2	907.9
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	.034	1.20	9.8	.2	.5	1.7	4.1	17.5
AS-41-S (Vol 2, p 3.37) Schwarzschild Camera	.103	1.25	9.8	.5	1.4	5.6	14.5	33.1
(Vol 2, p 3.25) Small IR Cryo. Telesc.	.00003	1.35	10.5	.0	.0	.0	.0	11.9
(Vol 2, p 3.27) EUV Imag. Telesc.	PP .045 A .00006	1.25	10.5	.3	1.3	1.1	.0	14.5
(Vol 2, p 3.30) EUV Spectrometer	PP .029 A .00001	1.25	4.9	.2	.8	.9	.0	8.1
(Vol 2, p 3.33) UV Photometer	PP .00008 A 2×10^{-7}	1.10	6.3	.0	.0	.0	.0	7.4
(Vol 2, p 3.42) Microchannel Spectr.	PP 8.352 A .00002	1.20	14.0	50.1	233.9	167.0	.0	466.2
(Vol 2, p 3.43) UV Polarimeter	.002	1.20	6.3	.0	.1	.0	.1	7.7
(Vol 2, p 3.47) IUE Spectrograph	.003	1.25	14.7	.0	.1	.2	.6	16.9
AS-15-S Amb. Temp. IR Telesc.	.041	1.85	14.7	.2	1.7	2.4	8.0	28.9
AS-09-S 30m IR LBI	.19	1.40	14.7	1.0	5.3	9.1	6.1	37.6
AS-03-S DUST	8.45	1.35	14.0	42.2	118.3	456.3	1529.4	2161.6
AS-01-S SIRTF	.035	1.90	14.7	.2	1.5	2.6	8.0	28.9
AS-05-S Very Wd. Field Gal. Cam	.295	1.25	14.0	1.5	4.1	17.1	39.8	77.8

TABLE 5-23 DATA VOLUMES, BLOCK WEIGHTS, AND SCORES FOR HIGH ENERGY ASTROPHYSICS SORTIES

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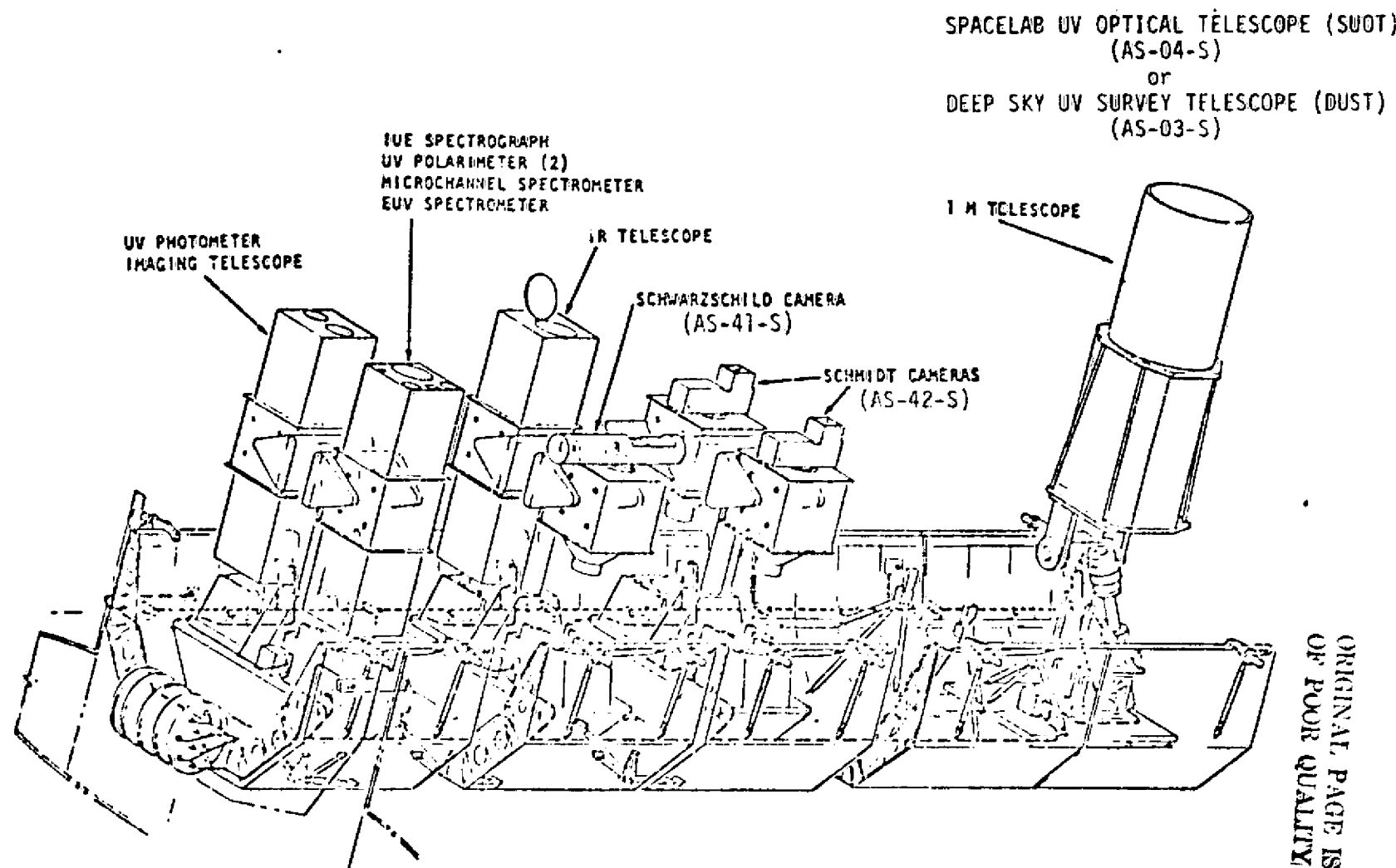


FIGURE 5-7 RED BOOK ASTRONOMY "GROUP III" SORTIE FLIGHT CARGO

TABLE 5-24

SPACELAB HIGH ENERGY ASTROPHYSICS
DEDICATED MISSION PAYLOADS

I. PAYLOAD A		
GSFC I.D.	1973 Woods I.D.	Description
G II.	SX-3	HIGH ENERGY SOURCES
G III.	SX-7	BRAGG SPECTROMETER
G IV.	SG-8 & 9	HIGH ENERGY GAMMA RAYS
G V.	SG 5 & 8	LOW ENERGY GAMMA RAYS & NUCLEAR LINES
G VII.	SC 1 & 4	TRANSITION RADIATION ELECTRON SPECTROMETER
II. PAYLOAD B		
G I.	SX-1	LARGE AREA X-RAY WITH CONCENTRATOR
G VI.	SC 1 & 4	IONIZATION SPECTROMETER
G VIII.	SC-4	NEGATRON POSITRON
G IX.	SC-2	ISOTOPE ABUNDANCE

TABLE 5-25 ASTRONOMY SORTIE FLIGHT MODEL

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRTF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	1				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	2	2			
AS-41-S (Vol 2, p 3.37) Schwartzschild Camera	1	1			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	1	1			
(Vol 2, p 3.27) EUV Imag. Telesc.	1	1			
(Vol 2, p 3.30) EUV Spectrometer	1	1			
(Vol 2, p 3.33) UV Photometer	1	1			
(Vol 2, p 3.42) Microchannel Spectr.	1	1			
(Vol 2, p 3.43) UV Polarimeter	2	2			
(Vol 2, p 3.47 IUE Spectrograph	1	1			
AS-15-S Amb. Temp. IR Telesc.					1
AS-09-S 30m IR LBI				1	
AS-03-S DUST		1			
AS-01-S SIRTF			1		
AS-05-S Verv Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	12	12	1	1	1

*Volume, page refer to Red Books

also be possible to have combined astronomy/high energy astrophysics sortie flights, but it is apparent from the scores in Tables 5-22 and 5-23 that the requirements imposed by astronomy alone flights will be greater than for combined flights whose requirements would be diluted by the relatively low score high energy astrophysics payloads. Therefore, combined missions are ignored. Tables 5-24 and 5-25 are used for summing the block weights over the seven candidate flights for discipline sortie weights just as Tables 2-1 and 2-2 were used to obtain the discipline weights for the corresponding free fliers.

The resulting flight data volumes and net requirements for each process block and each flight are summarized in Tables 5-26 to 5-32 for the astronomy sorties and in Tables 5-33 to 5-39 for the high energy astrophysics sorties. The Red Book "Group III" flight and its modified version show about the same premission and real time operations requirements, and both are far above the other astronomy flights. The modified "Group III" mission exhibits the greatest data volume and utilization of all other processing functions, although the unmodified version is not far behind. Thus, at this point these two missions are considered the astronomy drivers. Of the high energy astrophysics flights the tables show that "Payload A" is the driver mission for that discipline.

5.8 Driver Payloads

The driver groupings found in the previous sections are summarized in Table 5-40. The task at hand is to select individual driver payloads from these groups, as described in Section 4. The chosen payloads, along with the reasons, are:

- o Cryogenically Cooled IR Telescope - highest data volume and processing requirements (score), representative IR facility, continuous usage after 1985, responsible for making 1985 a driver year, driver in all blocks.

TABLE 5-26 DATA VOLUMES FOR ASTRONOMY SORTIES
(UNITS OF 10^{12} BITS/YR)

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRTF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	2.18				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	.07	.07			
AS-41-S (Vol 2, p 3.37) Schwartzschild Camera	.10	.10			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	.00	.00			
(Vol 2, p 3.27) EUV Imag. Telesc.	.04	.04			
(Vol 2, p 3.30) EUV Spectrometer	.03	.03			
(Vol 2, p 3.33) UV Photometer	.00	.00			
(Vol 2, p 3.42) Microchannel Spectr.	8.35	8.35			
(Vol 2, p 3.43) UV Polarimeter	.00	.00			
(Vol 2, p 3.47) IUE Spectrograph	.00	.00			
AS-15-S Amb. Temp. IR Telesc.					.04
AS-09-S 30m IR LBI				.19	
AS-03-S DUST		8.45			
AS-01-S SIRTF			.04		
AS-05-S Very Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	10.77	17.04	.04	.19	.04

*Volume, page refer to Red Books

TABLE 5-27 PERMISSION REQUIREMENTS FOR ASTRONOMY SORTIES
(UNITS OF 10^{12} /YR)

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRTF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	1.85				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	2.40	2.40			
AS-41-S (Vol 2, p 3.37) Schwartzschild Camera	1.25	1.25			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	1.35	1.35			
(Vol 2, p 3.27) EUV Imag. Telesc.	1.25	1.25			
(Vol 2, p 3.30) EUV Spectrometer	1.25	1.25			
(Vol 2, p 3.33) UV Photometer	1.10	1.10			
(Vol 2, p 3.42) Microchannel Spectr.	1.20	1.20			
(Vol 2, p 3.43) UV Polarimeter	2.40	2.40			
(Vol 2, p 3.47) IUE Spectrograph	1.25	1.25			
AS-15-S Amb. Temp. IR Telesc.					1.25
AS-09-S 30m IR LBI				1.40	
AS-03-S DUST		1.35			
AS-01-S SIRTF			1.90		
AS-05-S Very Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	15.30	14.80	1.90	1.40	1.85

*Volume, page refer to Red Books

TABLE 5-28 REAL TIME OPERATIONS REQUIREMENTS FOR ASTRONOMY SORTIES
(UNITS OF 10^{12} /YR)

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRTF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	19.7				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	19.6	19.6			
AS-41-S (Vol 2, p 3.37) Schwartzschild Camera	9.8	9.2			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	10.5	10.5			
(Vol 2, p 3.27) EUV Imag. Telesc.	10.5	10.5			
(Vol 2, p 3.30) EUV Spectrometer	4.9	4.9			
(Vol 2, p 3.33) UV Photometer	6.3	6.3			
(Vol 2, p 3.42) Microchannel Spectr.	14.0	14.0			
(Vol 2, p 3.43) UV Polarimeter	12.6	12.6			
(Vol 2, p 3.47) IUE Spectrograph	14.7	14.7			
AS-15-S Amb. Temp. IR Telesc.					14.7
AS-09-S 30m IR LBI				14.7	
AS-03-S DUST		14.0			
AS-01-S SIRTF			14.7		
AS-05-S Very Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	117.6	117.6	14.7	14.7	14.7

*Volume, page refer to Red Books

TABLE 5-29 REAL TIME DATA HANDLING REQUIREMENTS FOR ASTRONOMY SORTIES
(UNITS OF 10^{12} /YR)

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRIF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	10.9				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	.4	.4			
AS-41-S (Vol 2, p 3.37) Schwartzschild Camera	.5	.5			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	.0	.0			
(Vol 2, p 3.27) EUV Imag. Telesc.	.3	.3			
(Vol 2, p 3.30) EUV Spectrometer	.2	.2			
(Vol 2, p 3.33) UV Photometer	.0	.0			
(Vol 2, p 3.42) Microchannel Spectr.	50.1	50.1			
(Vol 2, p 3.43) UV Polarimeter	.0	.0			
(Vol 2, p 3.47) IUE Spectrograph	.0	.0			
AS-15-S Amb. Temp. IR Telesc.					.2
AS-09-S 30m IR LBI				1.0	
AS-03-S DUST		42.2			
AS-01-S SIRTF			.2		
AS-05-S Very Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	62.4	93.7	.2	1.0	.2

*Volume, page refer to Red Books

TABLE 5-30 QUICK LOOK REQUIREMENTS FOR ASTRONOMY SORTIES
(UNITS OF 10^{12} /YR)

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRIF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	61.0				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	1.0	1.0			
AS-41-S (Vol 2, p 3.37) Schwarzschild Camera	1.4	1.4			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	.0	.0			
(Vol 2, p 3.27) EUV Imag. Telesc.	1.3	1.3			
(Vol 2, p 3.30) EUV Spectrometer	.8	.8			
(Vol 2, p 3.33) UV Photometer	.0	.0			
(Vol 2, p 3.42) Microchannel Spectr.	233.9	233.9			
(Vol 2, p 3.43) UV Polarimeter	.2	.2			
(Vol 2, p 3.47) IUE Spectrograph	.1	.1			
AS-15-S Amb. Temp. IR Telesc.					1.7
AS-09-S 30m IR LBI				5.3	
AS-03-S DUST		118.3			
AS-01-S SIRTF			1.5		
AS-05-S Very Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	299.7	357.0	1.5	5.3	1.7

*Volume, page refer to Red Books

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TABLE 5-31 PREPROCESSING REQUIREMENTS FOR ASTRONOMY SORTIES
(UNITS OF 10^{12} /YR)

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRIF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	135.2				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	3.4	3.4			
AS-41-S (Vol 2, p 3.37) Schwarzschild Camera	5.6	5.6			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	.0	.0			
(Vol 2, p 3.27) EUV Imaq. Telesc.	1.1	1.1			
(Vol 2, p 3.30) EUV Spectrometer	.9	.9			
(Vol 2, p 3.33) UV Photometer	.0	.0			
(Vol 2, p 3.42) Microchannel Spectr.	167.0	167.0			
(Vol 2, p 3.43) UV Polarimeter	.0	.0			
(Vol 2, p 3.47) IUE Spectrograph	2	.2			
AS-15-S Amb. Temp. IR Telesc.					2.4
AS-09-S 30m IR LBI				9.1	
AS-03-S DUST		456.3			
AS-01-S SIRTF			2.6		
AS-05-S Very Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	313.4	634.5	4.6	9.1	2.4

*Volume, page refer to Red Books

TABLE 5-32 ANALYSIS REQUIREMENTS FOR ASTRONOMY SORTIES
(UNITS OF 10^{12} /YR)

Payloads*	Candidate Flights				
	Red Book "Group III" (SUOT + Small P/L's)	Modified "Group III" (DUST + Small P/L's)	SIRIF Alone	30m IR LBI Alone	Ambient Temperature IR Telesc. Alone
AS-04-S SUOT	584.2				
AS-42-S (Vol 2, p 3.17) Schmidt Camera/Spectr.	8.2	8.2			
AS-41-S (Vol 2, p 3.37) Schwarzschild Camera	14.5	14.5			
(Vol 2, p 3.25) Small IR Cryo. Telesc.	.0	.0			
(Vol 2, p 3.27) EUV Imag. Telesc.	.0	.0			
(Vol 2, p 3.30) EUV Spectrometer	.0	.0			
(Vol 2, p 3.33) UV Photometer	.0	.0			
(Vol 2, p 3.42) Microchannel Spectr.	.0	.0			
(Vol 2, p 3.43) UV Polarimeter	.2	.2			
(Vol 2, p 3.47) IUE Spectrograph	.6	.6			
AS-15-S Amb. Temp. IR Telesc.					8.0
AS-09-S 30m IR LBI				6.1	
AS-03-S DUST		1529.4			
AS-01-S SIRTF			8.0		
AS-05-S Very Wd. Field Gal. Cam.	Module mounting only.				
Flight Total	607.7	1532.9	8.0	6.1	8.0

*Volume, page refer to Red Books

TABLE 5-33 DATA VOLUMES FOR HIGH ENERGY ASTROPHYSICS SORTIES
(UNITS OF 10^{12} BITS/YR)

Payloads	Candidate Flights	
	Red Book "Payload A"	Red Book "Payload B"
SX-3/GII Hi Energy Sources	.063	
SX-7/GIII Polarim/Bragg Spectr.	.006	
SG8 & 9/GIV Hi En. Gamma Rays	.010	
SG5 & 8/GV Low En. Gam. Ray & Nuc.	.025	
SC1 & 4/GVII Trans. Rad. Spectr.	.063	
SX1/GI Lg Area X-Ray w/Concentr.		.019
SC1 & 4/GVI Ioniz. Spectrometer		.015
SC4/GVIII Negatron/Position		.013
SC2/GIX Isotope Abundance		.013
Flight Total	.167	.060

TABLE 5-34 PREMISSION REQUIREMENTS FOR HIGH ENERGY ASTROPHYSICS SORTIES
(UNITS OF 10^{12} /yr)

Payloads	Candidate Flights	
	Red Book "Payload A"	Red Book "Payload B"
SX-3/GII Hi Energy Sources	1.25	
SX-7/GIII Polarim/Bragg Spectr.	1.25	
SG8 & 9/GIV Hi En. Gamma Rays	1.40	
SG5 & 8/GV Low En. Gam. Ray & Nuc.	1.30	
SC1 & 4/GVII Trans. Rad. Spectr.	1.60	
SX1/GI Lg Area X-Ray w/Concentr.		1.15
SC1 & 4/GVI Ioniz. Spectrometer		1.15
SC4/GVIII Negatron/Position		1.30
SC2/GIX Isotope Abundance		1.60
Flight Total	6.80	5.20

TABLE 5-35 REAL TIME OPERATIONS REQUIREMENTS FOR HIGH ENERGY ASTROPHYSICS SORTIES
(UNITS OF 10^{12} /YR)

Payloads	Candidate Flights	
	Red Book "Payload A"	Red Book "Payload B"
SX-3/GII Hi Energy Sources	9.1	
SX-7/GIII Polarim/Bragg Spectr.	9.1	
SG8 & 9/GIV Hi En. Gamma Rays	9.9	
SG5 & 8/GV Low En. Gam. Ray & Nuc.	9.1	
SC1 & 4/GVII Trans. Rad. Spectr.	4.9	
SX1/GI Lg Area X-Ray w/Concentr.		9.1
SC1 & 4/GVI Ioniz. Spectrometer		4.9
SC4/GVIII Negatron/Position		4.9
SC2/GIX Isotope Abundance		4.9
Flight Total	42.0	23.8

TABLE 5-36 REAL TIME DATA HANDLING REQUIREMENTS FOR HIGH
ENERGY ASTROPHYSICS SORTIES (UNITS OF 10^{12} /YR)

Payloads	Candidate Flights	
	Red Book "Payload A"	Red Book "Payload B"
SX-3/GII Hi Energy Sources	.32	
SX-7/GIII Polarim/Bragg Spectr.	.04	
SG8 & 9/GIV Hi En. Gamma Rays	.06	
SG5 & 8/GV Low En. Gam. Ray & Nuc.	.15	
SC1 & 4/GVII Trans. Rad. Spectr.	.38	
SX1/GI Lg Area X-Ray w/Concentr.		.11
SC1 & 4/GVI Ioniz. Spectrometer		.09
SC4/GVIII Negatron/Position		.08
SC2/GIX Isotope Abundance		.08
Flight Total	1.01	.36

TABLE 5-37 QUICK LOOK REQUIREMENTS FOR HIGH ENERGY
ASTROPHYSICS SORTIES (UNITS OF 10^{12} /YR)

Payloads	Candidate Flights	
	Red Book "Payload A"	Red Book "Payload B"
SX-3/GII Hi Energy Sources	1.76	
SX-7/GIII Polarim/Bragg Spectr.	.17	
SG8 & 9/GIV Hi En. Gamma Rays	.28	
SG5 & 8/GV Low En. Gam. Ray & Nuc.	.70	
SC1 & 4/GVII Trans. Rad. Spectr.	1.76	
SX1/GI Lg Area X-Ray w/Concentr.		.57
SC1 & 4/GVI Ioniz. Spectrometer		.21
SC4/GVIII Negatron/Position		.36
SC2/GIX Isotope Abundance		.36
Flight Total	4.67	1.46

TABLE 5-38 PREPROCESSING REQUIREMENTS FOR HIGH ENERGY
ASTROPHYSICS PAYLOADS (UNITS OF 10^{12} /YR)

Sorted

Payloads	Candidate Flights	
	Red Book "Payload A"	Red Book "Payload B"
SX-3/GII Hi Energy Sources	3.28	
SX-7/GIII Polarim/Bragg Spectr.	.20	
SG8 & 9/GIV Hi En. Gamma Rays	.48	
SG5 & 8/GV Low En. Gam. Ray & Nuc.	.55	
SC1 & 4/GVII Trans. Rad. Spectr.	1.76	
SX1/GI Lg Area X-Ray w/Concentr.		.65
SC1 & 4/GVI Ioniz. Spectrometer		.39
SC4/GVIII Negatron/Position		.29
SC2/GIX Isotope Abundance		.39
Flight Total	6.27	1.72

TABLE 5-39 ANALYSIS REQUIREMENTS FOR HIGH ENERGY
ASTROPHYSIC SORTIES (UNITS OF 10^{12} /YR)

Payloads	Candidate Flights	
	Red Book "Payload A"	Red Book "Payload B"
SX-3/GII Hi Energy Sources	9.14	
SX-7/GIII Polarim/Bragg Spectr.	.80	
SG8 & 9/GIV Hi En. Gamma Rays	1.55	
SG5 & 8/GV Low En. Gam. Ray & Nuc.	3.80	
SC1 & 4/GVII Trans Rad. Spectr.	7.18	
SX1/GI Lg Area X-Ray w/Concentr.		.87
SC1 & 4/GVI Ioniz. Spectrometer		1.83
SC4/GVIII Negatron/Position		1.59
SC2/GIX Isotope Abundance		1.29
Flight Total	22.47	5.52

TABLE 5-40 SUMMARY OF ASTRONOMY AND HIGH ENERGY ASTROPHYSICS DRIVER GROUPS

	PREMISSION FUNCTIONS	REAL TIME OPERATIONS	DATA VOLUME AND DATA PROCESSING
Astronomy (AS) Free Fliers	1985 (early jump) 1988 (highest peak)	1985 (early jump, almost highest peak)	1985 (early jump) 1987 (highest peak)
High Energy Astrophysics (HE) Free Fliers	1980 (early peak)	1986 (highest peak)	1987 (jump to almost highest peak)
AS and HE Combined Free Fliers	1980 (early peak) 1990 (highest peak)	1989 (highest peak)	1987 (jump to highest peak)
AS Sorties	Red Book "Group III" Modified "Group III"	Red Book "Group III" Modified "Group III"	Modified "Group III"
HE Sorties	Red Book "Payload A"	Red Book "Payload A"	Red Book "Payload A"

- o Advanced Radio Astronomical Explorer (ARAE) - high data volume and requirements, representative of LBI's, continuous usage.
- o IR LBI - second driver in 1987 group, similar in principle to ARAE but with different (heterodyne optical quadratic rather than linear) detection technique.
- o Deep Sky Ultraviolet Survey Telescope (DUST) - high data volume (caused by high data storage on film) and processing requirements representative of objective spectrum instruments and of surveys.
- o Microchannel Spectrometer - high preprocessing data volume, real time data handling and preprocessing requirements.
- o Spacelab UV - Optical Telescope (SUOT) - high data volume and processing requirements (but not as high as DUST), diversity of focal plane sensors used, representative of general facility, higher pre-mission and real time operations requirements than DUST.
- o Cosmic Ray Laboratory - overshadows all other HE payloads during 1987 to 1991 period, representative cosmic ray facility.
- o Large X-Ray Telescope - presence in two driver groups (1986 and 1987), representative of x-ray facility.
- o Large High Energy Observatory (HEO) - B - premission driver, large processing requirements; however contains magnetic spectrometer as does the Cosmic Ray Laboratory.
- o High Energy Sources - highest processing requirements, representative of x-ray detection, utilizes spectral, spatial, and temporal analyses.

Consideration of astronomy and high energy astrophysics together yielded the Cosmic Ray Laboratory, the Cryogenically Cooled IR Telescope, and the Large HEO - B, all of which were already indicated above.

As noted in Section 4, the driver selection was also performed by ranking the payloads by net score. For that purpose the sortie scores were converted from a per mission to a per year basis by doubling (two missions per year). The resulting payload rankings are given in Tables 5-41 and 5-42 for astronomy and high energy astrophysics, respectively. Those payloads already pinpointed as drivers in the groupings are marked with asterisks. The presence of asterisks in the high end of each table denotes a high correlation between the two methods for choosing drivers. The same driver list defined earlier is retained with the following modifications. The SUOT is deleted, but both versions of the Red Book "Group III" astronomy mission (SUOT + small P/L's and DUST + small P/L's) are added. High Energy Sources alone is deleted, but the whole "Payload A", including that payload, is added. Although relatively high in the ranking, the IR LBI is deleted because of its similarity to the ARAE. The resulting final list of driver payloads is summarized, along with all the other disciplines in Section 8.

TABLE 5-41 ASTRONOMY RANKING

<u>Rank</u>	<u>Payload</u>	<u>Mode</u>	<u>Score</u>
* 1.	Modified "Group III" (DUST + Small P/L's)	S	5540.2
* 2.	DUST	S	4323.2
* 3.	Red Book "Group III" (SUOT + Small P/L's)	S	2832.8
* 4.	SUOT	S	1615.8
* 5.	Cryogenically Cooled IR Telescope	FF	1567.5
* 6.	Microchannel Spectrometer	S	932.4
* 7.	2 Advanced Radio Astronomy Explorers	FF	531.6
* 8.	IR LBI	FF	282.4
9.	Large Radio Observatory Array	FF	256.2
*10.	1 Advanced Radio Astr. Explorer	FF	265.8
11.	Ambient Temp. IR Telescope	FF	169.2
12.	Microwave LBI	FF	156.1
13.	Very Wide Field Gal. Cam.	S	155.6
14.	4 Cosmic Background Explorers	FF	152.0
15.	Submillimeter Telescope	FF	124.0
16.	Space Telescope	FF	98.4
17.	Extra Coronal Lyman Alpha Expl.	FF	95.0
18.	30m IR LBI	S	75.2
19.	Radio Explorer	FF	66.6
20.	Schwartzschild Camera	S	66.2
21.	SIRTF	S	57.8
22.	Amb. Temp. IR Telesc.	S	57.8
23.	1 Cosmic Background Expl.	FF	38.0
24.	Schmidt Camera/Spectrograph	S	35.0
25.	IUE Spectrograph	S	33.8
26.	EUV Imaging Telescope	S	29.0
27.	IUE	FF	27.2
28.	Small IR Cryo. Telescope	S	23.8
29.	IUE Photometry	FF	22.6
30.	EUV Spectrometer	S	16.2
31.	UV Polarimeter	S	15.4
32.	UV Photometer	S	14.8

*Drivers from groups

TABLE 5-42 HIGH ENERGY ASTROPHYSICS RANKING

<u>Rank</u>	<u>Payload</u>	<u>Mode</u>	<u>Score</u>
* 1.	Cosmic Ray Laboratory	FF	1547
* 2.	3 Large HEO-B's	FF	186
* 3.	Red Book "Payload A"	S	166
4.	Large HEO-A	FF	84
5.	Red Book "Payload B"	S	76
* 6.	Large X-Ray Telescope	FF	64
* 7.	1 Large HEO-B	FF	62
8.	Large HEO-C	FF	52
* 9.	High Energy Sources	S	50
10.	3 Small HE Satellites	FF	45
11.	Large HEO-D	FF	39
12.	Extended X-Ray Survey	FF	37
13.	Trans. Rad. Spectrometer	S	35
14.	Low Energy Gamma Rays	S	31
15.	High Energy Gamma Rays	S	27
16.	Large Area X-Ray w/Concentr.	S	25
17.	HEAO-C	FF	23
18.	Polarim./Bragg Spectr.	S	23
19.	Isotope Abundance	S	17
20.	Ionization Spectrometer	S	17
21.	Negatron/Positron	S	17
22.	1 Small HE Satellite	FF	15
23.	High Latt Cosmic Ray Survey	FF	6

*Drivers from groups

6. EARTH OBSERVATIONS, EARTH AND OCEAN PHYSICS, AND COMMUNICATION/NAVIGATION DISCIPLINES

The weighting process for these disciplines was identical to the previous section except for the use of a single "analysis" function. The analysis weight was chosen equal to the total preprocessing weight (exclusive of image digitization, which was provided only for film) because it is estimated that the total preprocessing and analysis operations will be comparable.

While the data rates were all taken from the SPDA, the total daily volume of Landsat D was considered insufficient for future use. Instead of the 1.13×10^{12} bits/day, one of the 3 Landsats was assumed to have 2.2×10^{12} bits/day. This corresponds to 10 minutes of use per orbit of the synthetic aperture radar and 20 minutes per orbit for the Thematic Mapper.

In these disciplines the payloads with data defined for NOAA have not been scored for data handling blocks. They have, however, been scored for premission and real time operations blocks as this will be handled by NASA.

Figure 6-1A gives the data rates as a function of time for Earth Observations, Figure 6-1B that of Earth and Ocean Physics. Table 6-1 gives the ratings assigned to the different processes. Tables 6-2, 6-3, 6-4, 6-5, 6-6, and 6-7 give the weights finally assigned each process and payload. The corresponding profiles are plotted in Figure 6-2. The score for Landsat D is so much larger than for the other payloads that the last four profiles which depend on data volume, coincide. They are:

- a. Real time data handling
- b. Quick look
- c. Preprocessing
- d. Analysis

Only one profile is given for these blocks. The driver selected for this discipline is Landsat D.

Tables 6-8, 6-9, 6-10, 6-11, 6-12, 6-13, and 6-14 and Figure 6-3 give these same data for the discipline of Earth and Ocean Physics. Similar to the Earth Observations discipline, the data load from Seasat B and Global Earth and Ocean Monitoring Satellite System is much greater than the sum of all other payloads of the discipline. Therefore the normalized profiles of the last four blocks again coincide. They have therefore not been given in separate plots.

Of the Communication and Navigation discipline the choice was limited to Search for Extra Terrestrial Intelligence (SETI).

Furthermore, of the Sortie flights the information of selected payloads was not yet available, and Earth Viewing Application Laboratory (EVAL) was therefore chosen.

PROCESS RELATIVE WEIGHT MATRIX

EARTH OBSERVATIONS

PAYLOAD \ PROCESS WEIGHT	PREMISSION					REAL TIME OPS	REAL TIME DATA HANDLING	QL	PREPROCESSING								Analysis	
	Mission Planning	DP System Development	Ops Training Support	Sensor Design Support	Sensor cal/test	Pointing/LGS Guidance Experiment Control	Pre-trans Handling; transm. Demux, etc.	Quick Look	Image Digitization	Geom Corr / Registr	Radiometric Corr	Image / Record Editing	Filtering, etc.	Fourier analysis	Arch. / Distrib.			
	6	6	2	1	2	6	1	1	2	14	8	10	2	6	4	12	2	36
LANDSAT D	3	3	1	2	3	3	3	2	2	3	0	3	3	3	3	3	3	3
SEOS	3	3	1	2	3	3	3	2	2	3	0	3	3	3	3	3	3	3
APPL. EXPL.	1	0	0	0	1	3	2	1	1	1	0	0	3	1	0	0	0	1
TIROS O	2	1	2	2	2	2	2	1	1	1	0	1	2	2	1	1	1	3
FOREIGN SYNCH. MET. SAT.	2	3	2	2	2	2	2											
GOES	2	3	2	2	2	2	2	DATA TO NOAA										
ERSOS (EARTH RES. SURVEY OP. SAT.	2	2	2	2	3	3	2	1	1	1	0	3	3	3	3	1	2	2
OP. ENV. SAT.	2	3	2	2	2	2	2	2	2	1	0	1	3	3	2	1	2	2
ADVANCED SYN. MET. SAT.	1	2	1	3	3	1	2	DATA TO NOAA										

TABLE 6-2

PAYLOAD	Data Volume (10^{12} bits/day)	Pre- mission	Real Time Ops	Real Time Data Handling	Quick Look	Pre- Processing	Analysis	Net Score Per Payload	Max. no. of Pay Loads	Total Score
LANDSAT D	776	46	21	6	42	108	108	1.7×10^{17}	4	6.8×10^{17}
SEOS	55.	46	21	6	42	108	108	1.5×10^{16}	3	4.5×10^{16}
APPL. RES. SAT.	7.	8	20	3	14	12	36			
TIROS - O	11	28	14	3	14	44	108	1.8×10^{15}	2	3.6×10^{15}
EARTH RESOURCES SURVEY OPER. SAT.	37	36	20	3	14	82	72	5.6×10^{15}	6	3.4×10^{16}
OPERATIONAL ENV. SAT.	18	40	14	6	14	58	72	2.9×10^{15}	3	8.1×10^{15}
FOREIGN SYNCHR. METEOR. SAT.		40	14							
GEO SYNCH. OPER. ENVIRONMENTAL SAT.		40	14							
ADVANCED SYNCH. MET. SAT.		29	8							

TABLE 6-3

ANNUAL REQUIREMENTS PROFILES

PREMISSION : EARTH OBSERVATION

payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
LANDSAT -D			46	46	46	92	0	92	92	92	0	92	0	92
SEOS			0	46	0	46	0	46	46	92	0	92	0	92
Appl. Res. Sat.			40	40	20	20	20	20	20	20	20	20	20	20
TIROS - O			0	0	21	0	21	0	0	21	0	0	0	0
Earth Resources Survey Oper. Sat.			27	27	27	108	54	54	54	54	54	54	54	54
Operational Env. Sat.			27	27	27	0	81	27	27	54	54	27	54	27
Foreign Synchr. Meteor. Sat.			0	40	40	0	80	40	80	0	80	0	80	0
Geosynch. Oper. Environmental Sat.			0	40	40	40	120	80	40	80	40	80	0	80
Advanced Synchr. Met. Sat.			0	0	0	0	0	0	0	29	0	0	0	0
PROFILE			140	266	221	306	376	359	359	442	248	365	208	365
Normalized Profile			.38	.60	.50	.69	.85	.81	.81	1.0	.56	.83	.47	.83

TABLE 6-4

ANNUAL REQUIREMENTS PROFILES

REAL TIME OPERATIONS: EARTH OBSERVATION

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
LANDSAT -D			63	84	63	63	63	63	63	63	63	63	63	63
SEOS			0	21	42	42	42	63	42	42	42	42	42	42
Appl. Res. Sat.			1.6	32	40	48	56	64	72	80	88	96	104	112
TIROS - O			12	12	24	24	12	12	12	24	24	24	24	24
Earth Resources Survey Oper. Sat.			80	100	120	100	100	100	100	100	100	100	100	100
Operational Env. Sat.			14	28	42	42	0	14	28	28	28	14	14	28
Foreign Synchr. Meteor. Sat.			14	28	42	42	42	28	28	28	28	28	28	28
Geosynch. Oper. Environmental Sat.			42	56	70	84	42	42	28	28	42	42	42	42
Advanced Synchr. Met. Sat.			8	8	8	8	8	8	8	16	16	16	16	16
PROFILE			249	381	430	453	365	394	381	409	431	425	370	392
Normalized Profile			.55	.84	.95	1.0	.81	.87	.84	.90	.95	.94	.82	.87

TABLE 6-5

ANNUAL REQUIREMENTS PROFILES

REAL TIME DATA HANDLING: EARTH OBSERVATION

payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
LANDSAT - D			396	528	396	396	396	396	396	396	396	396	396	396
SEOS			0	9.0	9.0	18.0	18.0	27	18	18	18	18	18	18
Appl. Res. Sat.														
TIROS - O			.9	.9	1.8	1.8	.9	.9	.9	1.8	1.8	1.8	1.8	1.8
Earth Resources Survey Oper. Sat.			12	15	18	15	15	15	15	15	15	15	15	15
Operational Env. Sat.			3.	6.	9.	9.	0	3	6	6	6	3	3	6
PROFILE			412	559	434	440	430	442	436	437	437	434	434	434
Normalized Profile														

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TABLE 6-6

ANNUAL REQUIREMENTS PROFILES

QUICK LOOK: EARTH OBSERVATIONS

payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
LANDSAT - D			198	264	198	198	198	198	198	198	198	198	198	198
SEOS			0	1.5	1.5	3.0	3.0	4.5	3.0	3.0	3.0	3.0	3.0	3.0
Appl. Res. Sat.														
TIROS - O			.3	.3	.6	.6	.3	.3	.3	.6	.6	.6	.6	.6
Earth Resources Survey Oper. Sat.			4.0	5.0	6.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Operational Env. Sat.			.5	1.0	1.5	1.5	0	.5	1.0	1.0	1.0	0.5	.5	1.0
PROFILE			203	272	208	208	206	209	207	208	208	207	207	207
Normalized Profile			.75	1.0	.77	.77	.77	.77	.77	.77	.77	.77	.77	.77

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TABLE 6-7

ANNUAL REQUIREMENTS PROFILES
PREPROCESSING: EARTH OBSERVATION

payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
LANDSAT - D			720	960	720	720	720	720	720	720	720	720	720	720
SEOS			0	17	17	34	34	51	34	34	34	34	34	34
Appl. Res. Sat.														
TIROS - O			1.2	1.2	2.4	2.4	1.2	1.2	1.2	2.4	2.4	2.4	2.4	2.4
Earth Resources Survey Oper. Sat.			32	40	48	40	40	40	40	40	40	40	40	40
Operational Env. Sat.			3	6	9	9	0	3	6	6	6	3	3	6
PROFILE			756	1024	796	804	795	815	801	802	802	799	799	802
Normalized Profile														

TABLE 6-8

ANNUAL REQUIREMENTS PROFILES

ANALYSIS: EARTH OBSERVATION

[illegible]

TABLE 6-10

[illegible]

TABLE 6-11

ANNUAL REQUIREMENTS PROFILES

PREMISSION: EARTH AND OCEAN PHYSICS

Payloads	CY	79	80	81	82	83	84	85	86	87	88	89	90	91
GEOPAUSE			13	13	26	26	26	26	26	26	26	26	26	26
GRAV. GRAD. SAT.			14	14	14	14	14	14	14	14	14	14	14	14
MINI LAGEOS			4	4	4	4	4	8	8	8	8	8	8	8
GRAV. FIELD SAT.			14	14	14	14	14	14	14	14	14	14	14	14
VECTOR MAGN. SAT.			0	42	42	0	0	0	42	0	0	0	42	42
MAGN. FIELD MON. SAT.			0	14	14	14	0	0	14	0	0	0	14	14
SEASAT 9			0	0	14	14	14	28	42	56	70	70	70	70
GLOBAL EARTH AND OCEAN MON. SAT.														
PROFILE			45	101	128	86	72	90	160	118	132	132	188	188
NORMALIZED PROFILE			.24	.54	.68	.46	.38	.48	.85	.63	.7	.7	1.0	1.0

TABLE 6-12

ANNUAL REQUIREMENTS PROFILES

REAL TIME DATA HANDLING: EARTH AND OCEAN PHYSICS

[illegible]

TABLE 6-13
ANNUAL REQUIREMENTS PROFILES
REAL TIME DATA HANDLING: EARTH AND OCEAN PHYSICS

[illegible]

2.

[illegible]

TABLE 6-16
ANNUAL REQUIREMENTS PROFILES
ANALYSIS: EARTH AND OCEAN PHYSICS

[illegible]

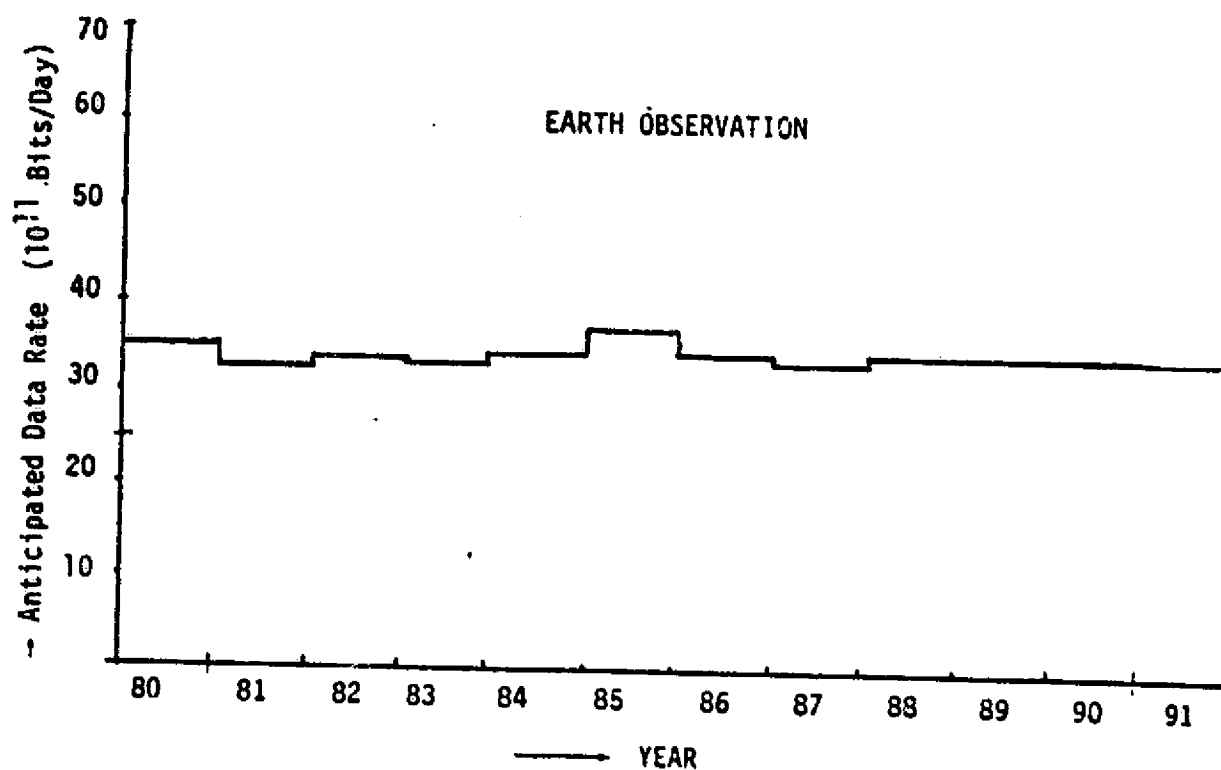


FIGURE 6-1A

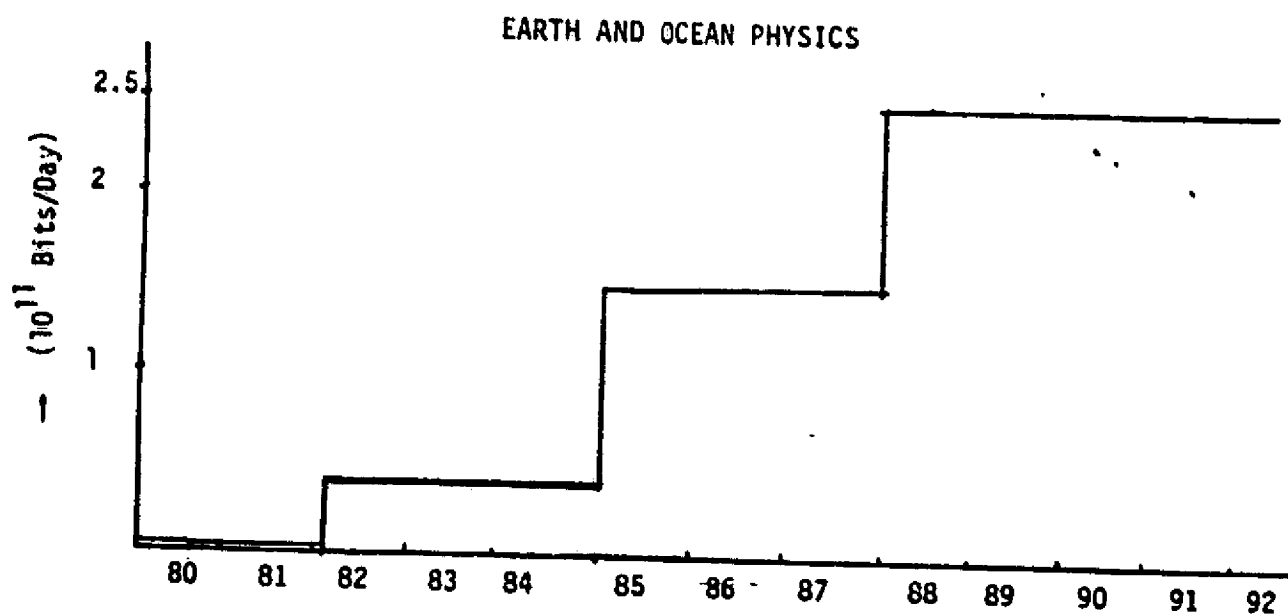


FIGURE 6-1B - ANTICIPATED DATA RATES IN BITS PER DAY

SUBJECTIVE RATINGS OF EARTH OBSERVATIONS

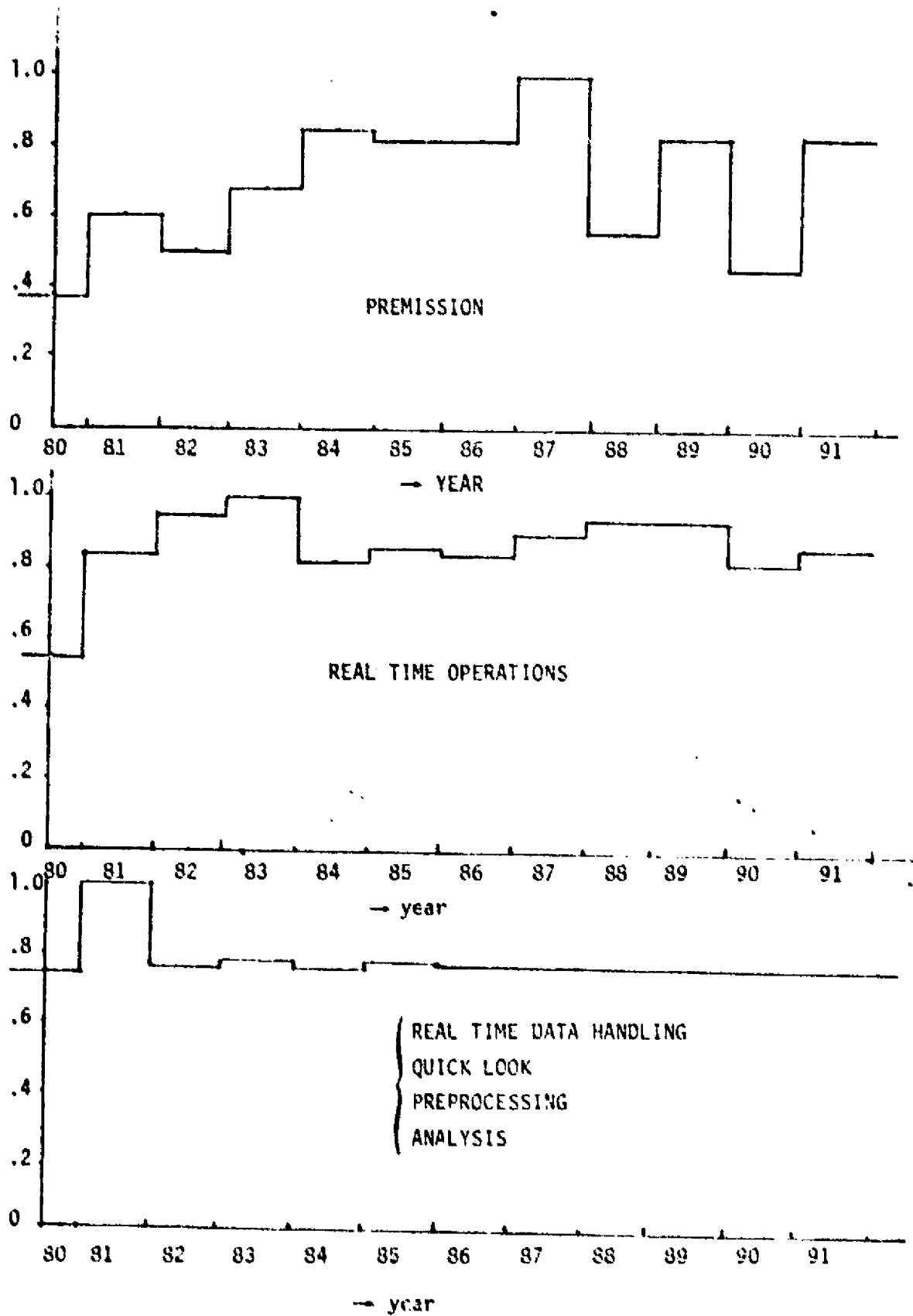


FIGURE 6-2
6-20

SUBJECTIVE RATING OF EARTH AND OCEAN PHYSICS

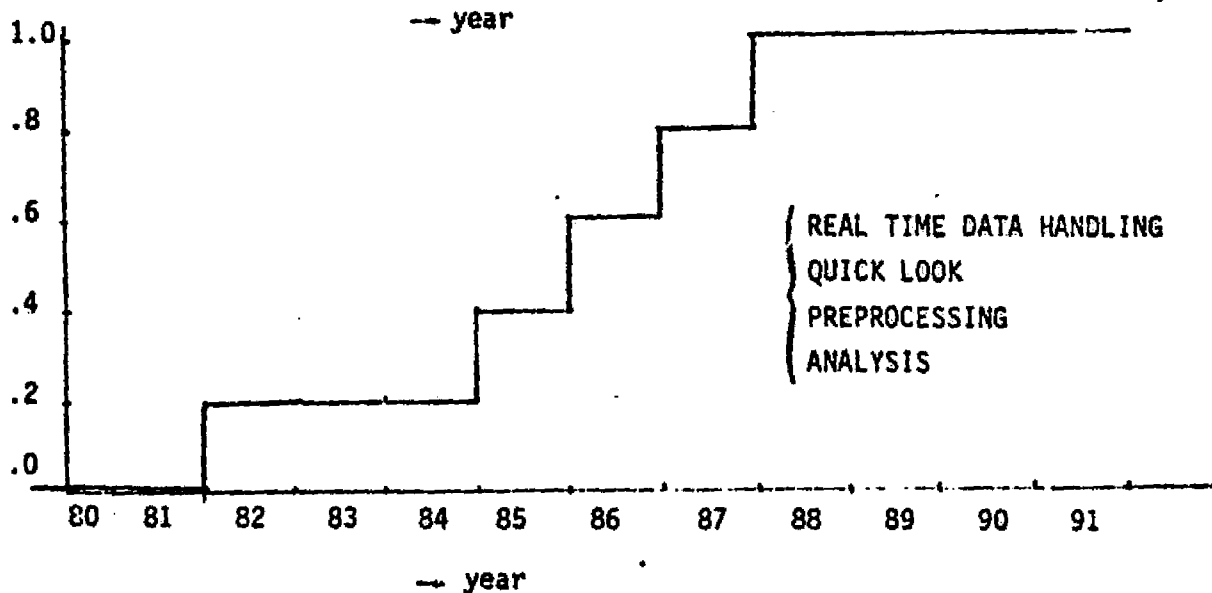
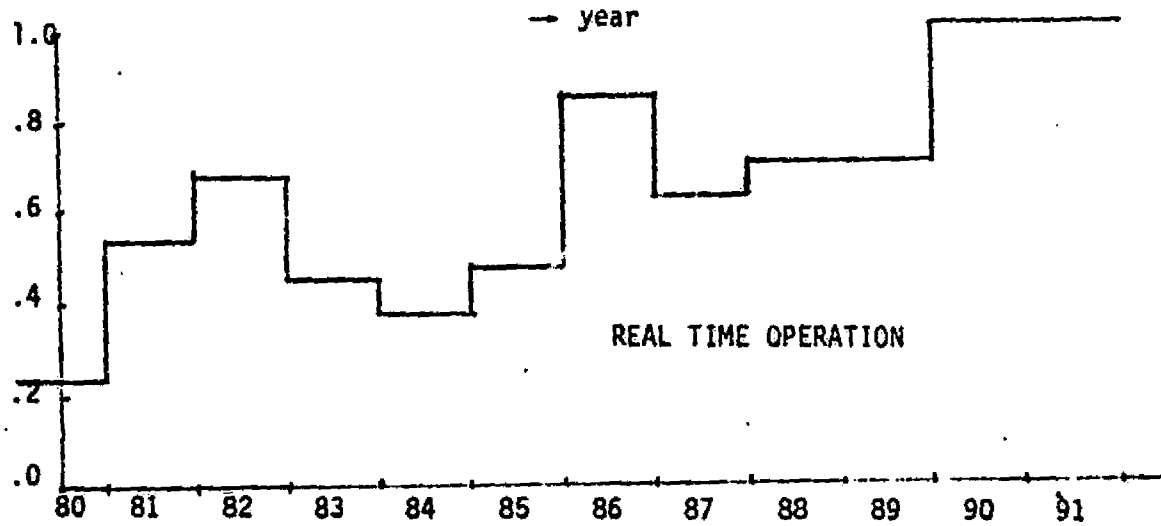
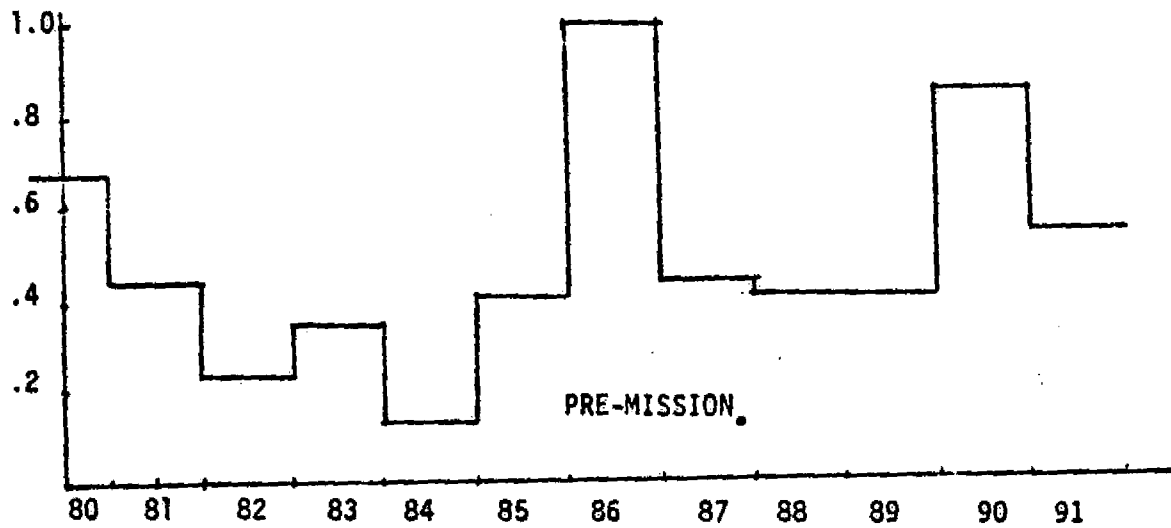


FIGURE 6-3
6-21

7. LUNAR EXPLORATION PROGRAM

An active program is continuing in an effort to analyze and to interpret the large amount of lunar data collected by the Ranger, Surveyor, Lunar Orbiter, and Apollo Missions. This effort is yielding an unprecedented expansion of new knowledge about the Moon and, in the process is raising many scientific questions and disagreements that can only be resolved by further investigations by lunar orbit and surface payloads. These missions would collect data similar to that from earlier missions as well as from new instrument types. Also, new geological provinces would be visited. Further, the payloads would supply the information needed for determining the locations, the technology requirements, and the scientific objectives for future manned lunar bases as well as the feasibility of exploiting lunar materials to support the bases.

7.1 Payload Descriptions and Data Volumes

During the period from 1979 to 1981 five types of payloads will be launched. These will include polar orbiters, high inclination orbiters, rovers, sample return probes, and halo satellites. In the sections to follow each of these payload types will be briefly described and data rates and volumes will be established. For all the orbiters an orbit period of 150 minutes and an altitude of 60 km will be assumed.

Lunar Orbiter (High Inclination)

The Lunar Orbiter consists of an Orbiter Bus of the Mariner type and a subsatellite similar to the one used with Apollo. The subsatellite will be used to obtain particle and magnetic field data. The instruments carried on the orbiter bus and their functions are listed in Table 7-1.

TABLE 7-1

<u>Instrument</u>	<u>Function</u>
1. Metric Camera	Photographic Mapping
2. Laser Altimeter	Calibrate Photography and Detect Gravity Variations
3. X-Ray Fluorescence Spectrometer	Map Abundances of Na, Mg, Al, etc.
4. Gamma Ray Spectrometer	Map Abundances of K, U, and Th
5. S-band Transponder	Position Determination
6. IR Scanning Radiometer	IR Mapping

The metric camera produces the highest data rate and data volume of the orbiter instruments. If we assume the FOV = 40 km and the IFOV = 10 m, the bit rate for 10-bit words is $1.9E7$ bits/sec, giving a volume of $8.3E11$ bits/day. The IR Radiometer produces the second largest data rate. If we assume the FOV = 40 km and the IFOV = 500 m, the bit rate for 10-bit words is $2.3E5$ bits/sec or the volume is $9.9E9$ bits/day. The other instruments produce significantly lower data rates and can be neglected in determining a worst case condition. Therefore, for the Lunar Orbiter the bit rate appears to be approximately $2E7$ bits/sec and the volume $3.1E14$ bits per year.

Lunar Polar Orbiter

The Lunar Polar Orbiter is composed of an Explorer type bus and spinner. The latter will be used for far side tracking and communicating with the orbiter bus. The instruments carried on the bus are listed in Table 7-2.

The Gamma-Ray Spectrometer is the data driver for the Polar Orbiter. If the FOV = 0.114° , the data rate is 45 bits/sec giving a volume of $4E6$ bits/day. The data rates of the other instruments are negligible compared to these two spectrometers. The payload data rate can be estimated as approximately 450 bits/sec and the volume as $1.4E10$ bits/year.

Lunar Rover

The Lunar Rover will travel up to 100 km/yr over the lunar surface to gather data for geophysics, geochemistry, and geology experiments. Its instrument complement is listed in Table 7-3.

The data driver for the Rover is the TV. Assuming a 100 km travel per year, a look every 10 m, 4 color frames in stereo per look, and $1E9$ bits per frame, the data volume is $12E11$ bits per year.

TABLE 7-2

<u>Instrument</u>	<u>Function</u>
1. X-Ray Spectrometer	Same as for Lunar Orbiter
2. Gamma-Ray Spectrometer	Same as for Lunar Orbiter
3. Magnetometer	Determine Absolute Vector Magnetic Field
4. Gravimeter	Determine Fine Structure of Gravity Field

TABLE 7-3

<u>Instrument</u>	<u>Function</u>
1. Panoramic Color Stereo TV	Geology Reconnaissance and Sample Examination
2. Surface Sampler	Acquire Samples
3. Sample Processer	Process Lunar Samples
4. X-Ray Dyfractometer	Determine Crystal Structure
5. X-Ray Spectrometer	Determine Composition of Surface Materials
6. Petrographic Microscope	Rock Classification
7. Automated Ion Probe	Age Dating and Elemental Abundance Determination
8. Active Seismic System	Lunar Stratigraphy
9. Magnetometer	Determine Vector Magnetic Field
10. Gravimeter	Data on Solid Body Tides and Gravitors
11. Soil Mechanics	Soil Bearing Strength, Adhesion, and Cohesion

TABLE 7-4 PAYLOAD WEIGHT MATRIX FOR LUNAR EXPLORATION PROGRAM

[illegible]

experiments as compared with the Polar Orbiter. The processing per bit is weighted below average as a whole. This results from much of the data being TV used for steering the Rover and observing details of the lunar surface. Neither of these functions require much processing. The Sample Return Probe has the same weights as the Rover.

Finally, the Halo Satellite has mostly zero weights since processing would only be required during Mission Planning and Pointing/LOS Guidance.

Table 7-5 gives the Process Block Weight Matrix which is computed directly from Table 7-4. From this matrix we observe that Premission Planning requires the greater amount of computer support in the first two groups, which are weighted per payload. In the last four groups, where the weighting is per data bit, we see that the Analysis groups requires significantly more computer support than the other groups.

Finally, Table 7-6 gives the Annual Requirements profile. The driver year is 1984. Plots of real time operations, premission, preprocessing and data volume are given in Figures 7.1 and 7.2.

TABLE 7-5 PROCESS BLOCK WEIGHT MATRIX FOR LUNAR EXPLORATION PROGRAM

[illegible]

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TABLE 7-6 ANNUAL REQUIREMENTS PROFILE FOR LUNAR EXPLORATION PROGRAM (1E12 BITS/YEAR)

[illegible]

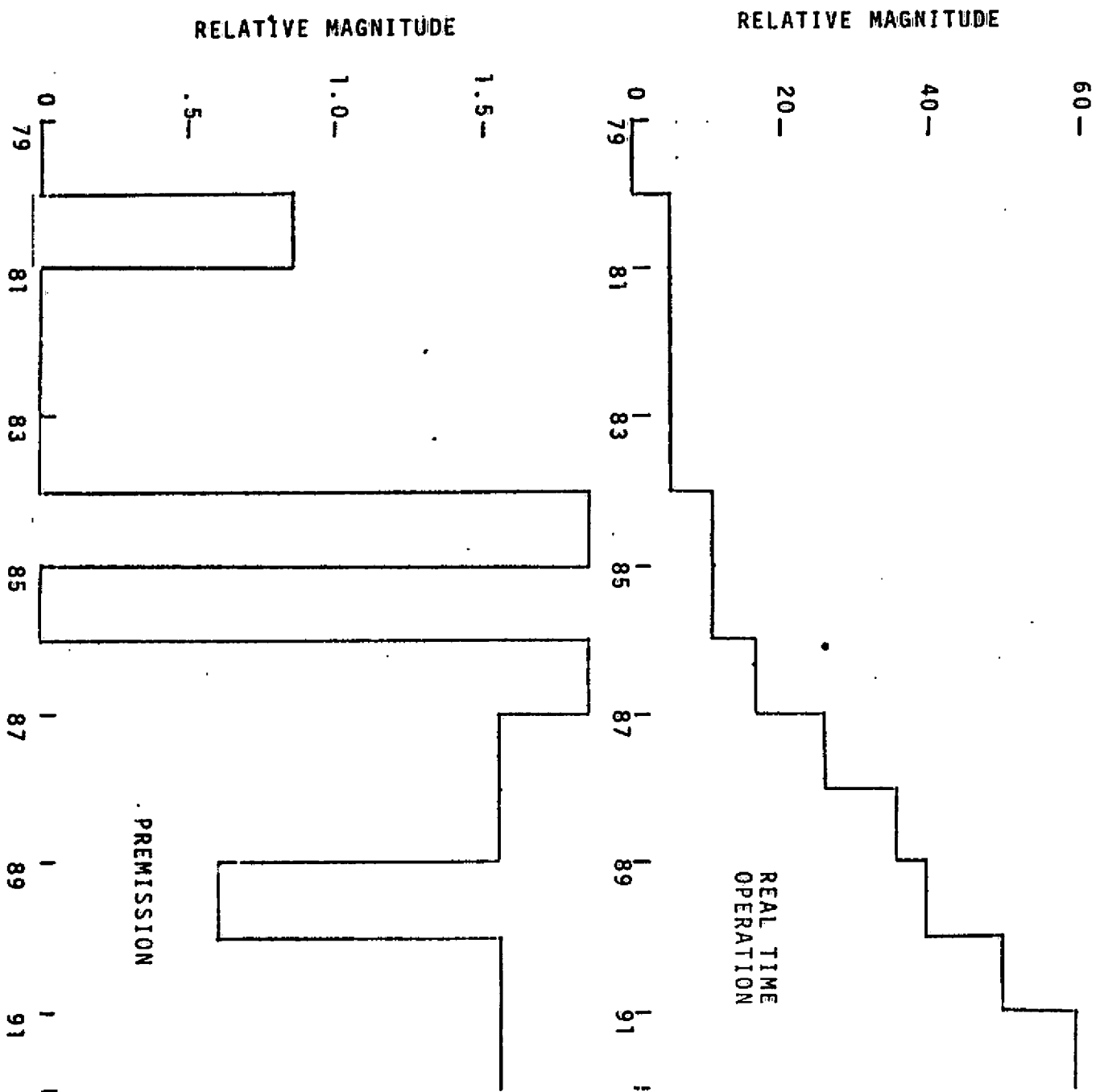


FIGURE 7-1 - Real-Time Operations and
Permission Annual Require-
ments Profile

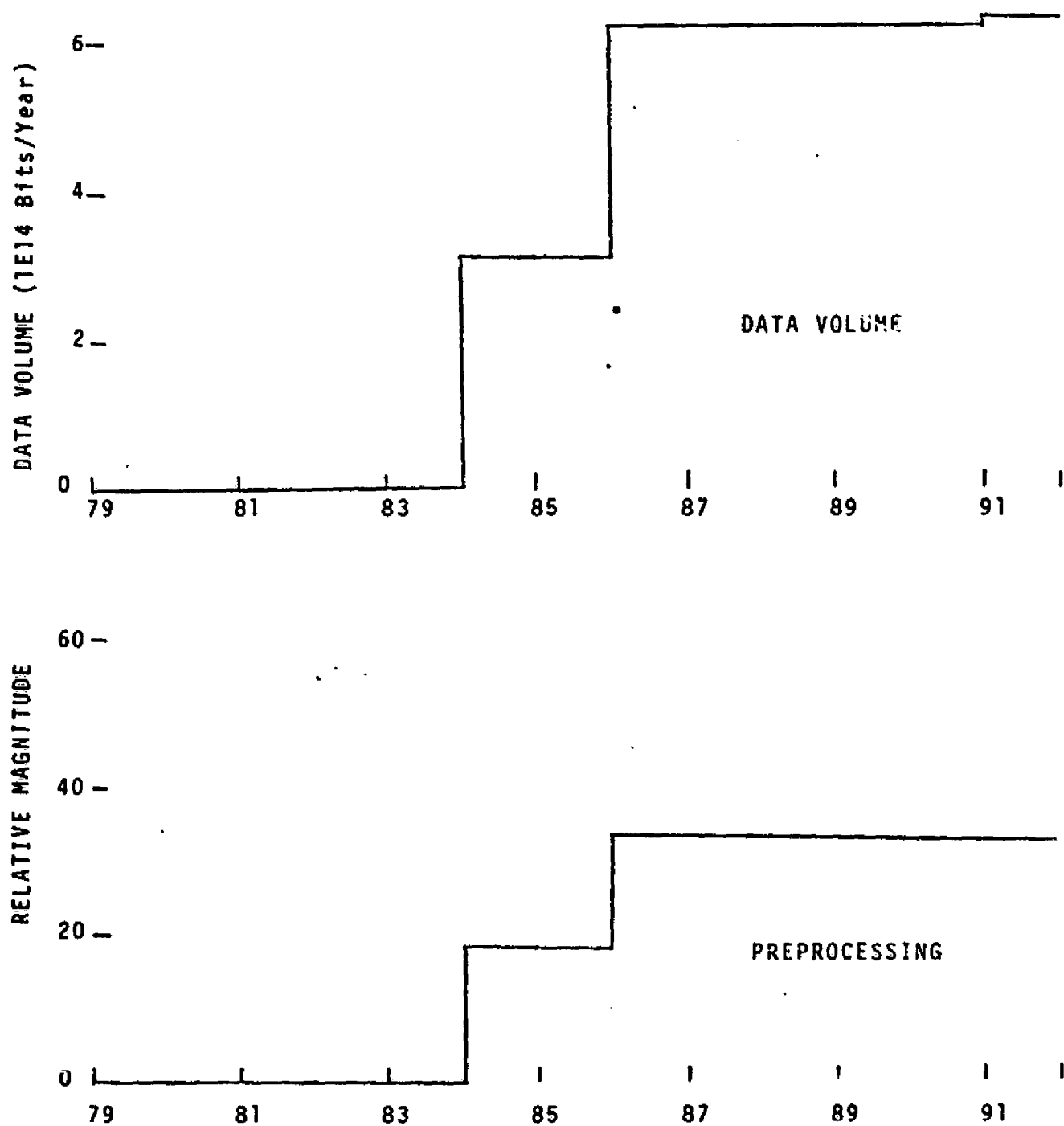


FIGURE 7-2 - Data Volume and Preprocessing Annual Requirements Profile

8. SUMMARY OF DRIVER PAYLOADS

The driver payloads found in Sections 5, 6, and 7 are summarized below along with notable descriptors. Each payload or sortie flight is related to the Technology Payload Model (TPM) derived in Reference 1.

Astronomy

- Modified version of typical sortie flight ("Group III") defined in Reference 8 and in Fig. 5-7 = AST - 10 in TPM. Contains Deep Space Ultraviolet Survey Telescope (DUST) + numerous small instruments.
 - representative of most astronomy experimentation
 - high data volume, high quantity of processing
 - representative of film and digital processing
 - onboard processing potential is high
- Deep Sky UV Survey Telescope (DUST)(AS-03-S) = AST - 10 in TPM.
 - leading data driver (high data volume on film)
 - spatial and spectral analysis
 - film processing
 - representative of all objective spectrum cameras
- Typical sortie flight ("Group III") defined in Fig. 5-7 = AST - 10. Contains Spacelab UV - Optical Telescope (SUOT)(AS-04-S) and small instruments.
 - same comments as first driver above with addition of large facility (SUOT) representation.
 - probably highest flight frequency.

- Large Cryogenic IR Telescope = 1054 in TPM. Free flier version of Spacelab IR Telescope Facility (SIRTF)(AS-01-S)
 - contains cameras, photometers, spectral interferometer
 - leading driver among free fliers (high data volume, processing diversity)
 - representative of most IR experimentation
- Microchannel Spectrometer - contained in sortie of Fig. 5-7. Far UV spectral dispersion with microchannel array plate photon - to - electron convertor followed by detector (anode strips or 4 corner anode voltage readout). (See Reference 8, Vol 2, p 3-42) = AST - 10 in TPM.
 - high sensor data output
 - large reduction of data in preprocessing
 - high onboard processing potential
 - representative of EUV experimentation
- Advanced Radio Astronomical Explorer (ARAE)(AS-05-A) = AST-1 in TPM. Radio long base interferometer (LBI)
 - representative of radio astronomy
 - representative of LBI, e.g. also in microwave
 - prototype to kilometer wave orbiting telescopes
 - interferogram processing
 - synchronous orbit with dedicated control.

High Energy Astrophysics

- Cosmic Ray Laboratory (HE-12-A) = PHY-5 in TPM.
 - leading data volume - overshadows all other HE
 - large facility - representative of most cosmic ray detection
 - diversity of processing requirements

- Large High Energy Observatory - B (magnetic spectrometer) (HE-09-A) = AST4 in TPM.
- three operating simultaneously - ops driver
- second highest data volume and processing requirements
- Dedicated High Energy Astrophysics Sortie defined by Reference B (called "Payload A") = AST-11 in TPM. Contains following instruments:

GSFC I.D.	1973 Woods I.D.	Description
G II.	SX-3	HIGH ENERGY SOURCES
G III.	SX-7	BRAGG SPECTROMETER
G IV.	SG 8 & 9	HIGH ENERGY GAMMA RAYS
G V.	SG 5 & 8	LOW ENERGY GAMMA RAYS & NUCLEAR LINES
G VII.	SC 1 & 4	TRANSITION RADIATION ELECTRON SPECTROMETER

- high data volume, diversity of processing, high processing requirement
- representative facility
- large onboard processing potential for data compression
- Large X-Ray Telescope (HE-01-A) = AST-9 in TPM.
- large general facility - spectral, spatial, temporal analysis
- representative of most X-Ray experimentation
- diversity of processing requirements
- present in two driver years ('86, '87)

Earth Observations

- LANDSAT D

- Chosen as driver because of its large effective data rate and total volume

- Earth Viewing Applications Laboratory (EVAL)

- At this time this is the only Sortie payload of which specifics are known. It is chosen at this time but may be deleted or changed later.

Earth and Ocean Physics

- SEASAT-B and Global Earth and Ocean monitoring system

- The reason for this choice is data rate and total volume.

- EVAL

- See Earth Observation

Communication/Navigation

- Search for Extraterrestrial Intelligence (SETI)

- Chosen because of its extreme interest and importance.

- EVAL

- See Earth Observation

Lunar Exploration

- Lunar Orbiter (LU-01-A) = LUN-2 in TPM. Contains metric camera, 30 band IR scanner, X-Ray detection for phosphorescence, laser altimeter, gamma-ray detection.
- highest data volume - overshadows all other instruments of AS, HE, LU
- contains imagery - maximal survey of lunar surface
- long duration operation

9. REFERENCES

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Aeronutronic

Intra Company

In reply refer to:

July 28, 1976

2K272/109

TO: File
FROM: J. C. Alvarez and E. M. Johnson
SUBJECT: Payload Ranking

1.0 Introduction

The purpose of this memorandum is to document the recommended Candidate Data Drivers List and the methodology used to develop this list.

1.1 Payload Disciplines

The payloads considered in this exercise are all of the line items in the Technology Payload Model (TPM) for the disciplines of Solar Physics (SO), Life Sciences (LS), Planetary Exploration (PL), Space Technology (ST), Space Processing (SP), and Atmospheric and Space Physics (AP). The TPM is documented in JSC IN 76-FM-36 "Development of the Technology Payload Model", dated May 27, 1976.

1.2 Payload Ranking Objective

The large number of line items in the TPM precludes an exhaustive analysis in the development of the Data System Technology Limitation RTOP. The approach adopted is one of scope and depth reduction which yields a manageable work load consistent with RTOP resources. This is effected by means of the driver payloads/mission concept. To this end, a ranking scheme was implemented to provide a list of possible technology driver payloads from which several of the most significant will be chosen for a more detailed analysis.

1.3 Data System Related Payload Functions

The ranking was based on the data handling load imposed by the payload with regard to the following data system related payload functions:

- a. Pointing and Control
- b. Calibration
- c. Quality Assurance/Performance Evaluation
- d. Process Automation
- e. Growth Potential
- f. Mission Planning
- g. Data Analysis
- h. Data Formatting
- i. Coordination with Ancillary Data
- j. Turnaround Time
- k. Mission Usage Rates
- l. Data Communication and Distribution
- m. Training
- n. Sensor Development
- o. Operations

2.0 Payload Ranking Scheme

The payload ranking index must be a function not only of relative cost, but also of relative need. The objective of this RTOP is to define technology areas which are necessary or beneficial to the accomplishment of disciplinary goals for the Shuttle Payloads. That is to say, technology development for each of the data system related payload functions is justified to the degree of the need that can be shown for this technology development.

A minimal exercise necessary to establish the cost of an advanced system (a system that has not been built nor prototyped yet) is composed of four steps: a) a parametric analysis that establishes the system parameters that predominate and the functional interdependence among these parameters; b) an operational analysis that establishes activity profiles, data pipeline rates and volumes, and also establishes functional requirements to a level suitable to permit the third step; c) a configuration analysis which defines candidate system blocks, and finally, d) a costing exercise which yields an estimate of resources required to implement the system under study.

2.1 The Ordered Pair Numeric and its Product

Establishment of rank requires a metric, and to this end an ordered pair numeric is defined useful in identifying candidate data system/mission drivers for the Data System Technology Limitation Study.

The ordered pair elements will be integers with values from 1 to 5. The first element will indicate how necessary a system related payload function is to the accomplishment of mission objectives as follows:

1. Mission goals are not impacted significantly by this function.
2. This function provides some increase in the value of data returns.
3. Some mission goals depend on this function.
4. Very few mission goals can be accomplished without this function.
5. This mission cannot be accomplished without this function.

The second element in the ordered pair will indicate how difficult it will be to provide this function for this payload as follows:

1. This is current state-of-the-art.
2. This is a reasonable extension of current state-of-the-art.

3. Moderate R&D is required before this function can be satisfied.
4. Providing this function represents either a large expense or a long lead time.
5. A technological break-through is required to satisfy this function requirement.

The simplest way to arrive at a metric that is a function of both relative need and relative cost is to multiply the two elements of this ordered pair by each other.

2.2 The Ranking Index

The ranking assessments are presented in Tables 1 through 64. Each table shows the assessment for a single line item in the TPM for the six disciplines listed in Section 1.1. For each data system related payload function, a need index and a cost index is assigned. The product of these two numbers is called the product index. The sum of products for a payload is called the overall payload ranking index and this has been used to order the payloads in order of decreasing rank. Table 1 presents the ranking assessment for (ST) 1009, "Solar Power Prototype Development", the highest ranking payload, and Table 64 presents the assessment for SP-21-5, "Space Processing Application No. 21 - Minimum Biological Module", the lowest ranking payload.

2.3 Index Load Profile

To arrive at an assessment of the function support load required as a function of time, the overall ranking index was multiplied by the number of that kind of payload that would have to be supported for each year. This is shown in Table 65, "Product Index Yearly Loading Profile".

Table 1

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) 1009

Payload Title: Solar Power Prototype Development

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	4	20
b. Calibration	5	4	20
c. Quality Assurance/Performance Evaluation	5	5	25
d. Process Automation	5	4	20
e. Growth Potential	5	4	20
f. Mission Planning	5	4	20
g. Data Analysis	5	2	10
h. Data Formatting	5	2	10
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	4	2	8
k. Mission Usage Rates	5	3	15
l. Data Communication and Distribution	4	3	12
m. Training	5	3	15
n. Sensor Development	4	3	12
o. Operations	5	4	20

OVERALL PAYLOAD RANKING INDEX

230

Table 2

RANKING ASSESSMENT

Discipline: Solar Physics

Payload Code: SO-02-A

Payload Title: Large Solar Observatories

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	2	10
b. Calibration	5	3	15
c. Quality Assurance/Performance Evaluation	4	3	12
d. Process Automation	4	3	12
e. Growth Potential	3	3	9
f. Mission Planning	5	3	15
g. Data Analysis	5	4	20
h. Data Formatting	5	3	15
i. Coordination with Ancillary Data	4	3	12
j. Turnaround Time	4	4	16
k. Mission Usage Rates	4	4	16
l. Data Communication and Distribution	3	4	12
m. Training	5	3	15
n. Sensor Development	3	3	9
o. Operations	5	4	20

OVERALL PAYLOAD RANKING INDEX

208

Table 3

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) 1008

Payload Title: Solar Power Space Test Activity

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	3	15
b. Calibration	5	3	15
c. Quality Assurance/Performance Evaluation	5	3	15
d. Process Automation	5	4	20
e. Growth Potential	5	5	25
f. Mission Planning	5	4	20
g. Data Analysis	4	2	8
h. Data Formatting	4	2	8
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	3	2	6
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	4	2	8
m. Training	5	3	15
n. Sensor Development	4	3	12
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

193

Table 4

RANKING ASSESSMENT

Discipline: Solar Physics

Payload Code: SO-01-S

Payload Title: Dedicated Solar Sortie Mission (DSSM)

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	2	10
b. Calibration	5	3	15
c. Quality Assurance/Performance Evaluation	4	3	12
d. Process Automation	2	3	6
e. Growth Potential	2	3	6
f. Mission Planning	5	4	20
g. Data Analysis	5	3	15
h. Data Formatting	5	3	15
i. Coordination with Ancillary Data	3	3	9
j. Turnaround Time	3	3	9
k. Mission Usage Rates	3	3	9
l. Data Communication and Distribution	2	4	8
m. Training	5	4	20
n. Sensor Development	3	3	9
o. Operations	5	4	20

OVERALL PAYLOAD RANKING INDEX

183

Table 5
RANKING ASSESSMENT

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Discipline: Space Technology

Payload Code: (ST) 1013

Payload Title: Power Relay Prototype Development

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	4	20
b. Calibration	5	3	15
c. Quality Assur- ance/Perform- ance Evaluation	5	3	15
d. Process Automa- tion	5	3	15
e. Growth Potential	5	3	15
f. Mission Planning	5	3	15
g. Data Analysis	3	2	6
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	4	2	8
k. Mission Usage Rates	5	2	10
l. Data Communication and Distribution	5	3	15
m. Training	5	2	10
n. Sensor Development	4	2	8
o. Operations	5	2	10

OVERALL PAYLOAD RANKING INDEX

176

Table 6
RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) 1012

Payload Title: Power Relay Space Testing

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	3	15
b. Calibration	5	2	10
c. Quality Assur- ance/Perform- ance Evaluation	5	4	20
d. Process Automa- tion	5	3	15
e. Growth Potential	5	3	15
f. Mission Planning	5	2	10
g. Data Analysis	3	2	6
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	5	2	10
k. Mission Usage Rates	5	2	10
l. Data Communication and Distribution	5	2	10
m. Training	4	2	8
n. Sensor Development	4	2	8
o. Operations	5	2	10

OVERALL PAYLOAD RANKING INDEX

161

Table 7

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: (SP) 1032

Payload Title: Commercial Processing Space Station

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	4	20
b. Calibration	5	2	10
c. Quality Assurance/Performance Evaluation	5	2	10
d. Process Automation	5	4	20
e. Growth Potential	5	1	5
f. Mission Planning	5	3	15
g. Data Analysis	5	2	10
h. Data Formatting	3	1	3
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	4	2	8
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	1	3
m. Training	5	3	15
n. Sensor Development	5	4	20
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

159

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Table 8 •

RANKING ASSESSMENT

ORIGINAL PAGE IS
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Discipline: Space Technology

Payload Code: (ST) 1114

Payload Title: Space Station - 12 Persons, Geosynchronous

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	4	20
b. Calibration	3	1	3
c. Quality Assur- ance/Perform- ance Evaluation	5	3	15
d. Process Automa- tion	4	2	8
e. Growth Potential	5	3	15
f. Mission Planning	5	4	20
g. Data Analysis	3	2	6
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	3	2	6
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	4	1	4
m. Training	5	2	10
n. Sensor Development	4	3	12
o. Operations	4	3	12

OVERALL PAYLOAD RANKING INDEX

150

Table 9

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: (SP) 1034

Space Station

Payload Title: "Long Term" Biological Materials Research

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	3	15
b. Calibration	5	2	10
c. Quality Assur- ance/Perform- ance Evaluation	5	3	15
d. Process Automa- tion	3	2	6
e. Growth Potential	4	2	8
f. Mission Planning	5	2	10
g. Data Analysis	5	4	20
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	5	2	10
j. Turnaround Time	4	2	8
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	2	6
m. Training	5	1	5
n. Sensor Development	4	3	12
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

149

Table 10

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: (SP) 1031

Payload Title: "Long Term" Low-g Material Science Research
Space Station

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	3	15
b. Calibration	5	2	10
c. Quality Assur- ance/Perform- ance Evaluation	5	3	15
d. Process Automa- tion	3	2	6
e. Growth Potential	4	2	8
f. Mission Planning	5	2	10
g. Data Analysis	5	4	20
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	5	2	10
j. Turnaround Time	4	2	8
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	2	6
m. Training	5	1	5
n. Sensor Development	4	3	12
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

149

Table 11

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: (SP) 1029

Payload Title: "Long Term" Physical Chemical Research Space
Station

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	3	15
b. Calibration	5	2	10
c. Quality Assurance/Performance Evaluation	5	3	15
d. Process Automation	3	2	6
e. Growth Potential	4	2	8
f. Mission Planning	5	2	10
g. Data Analysis	5	4	20
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	5	2	10
j. Turnaround Time	4	2	8
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	2	6
m. Training	5	1	5
n. Sensor Development	4	3	12
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

149

Table 12

RANKING ASSESSMENT

Discipline: Solar Physics

Payload Code: (S0)1076

Payload Title: Solar Monitor (50 kg. carry on)

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	5	3	15
c. Quality Assurance/Performance Evaluation	4	2	8
d. Process Automation	5	3	15
e. Growth Potential	3	2	6
f. Mission Planning	4	3	12
g. Data Analysis	5	3	15
h. Data Formatting	4	2	8
i. Coordination with Ancillary Data	4	3	12
j. Turnaround Time	2	2	4
k. Mission Usage Rates	3	2	6
l. Data Communication and Distribution	3	2	6
m. Training	3	3	9
n. Sensor Development	3	3	9
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

145

Table 13
RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) 1113

Payload Title: Space Station - 12 Persons, Earth Orbit

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	4	20
b. Calibration	2	1	3
c. Quality Assur- ance/Perform- ance Evaluation	5	3	15
d. Process Automa- tion	3	2	6
e. Growth Potential	4	3	12
f. Mission Planning	5	3	15
g. Data Analysis	3	2	6
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	3	2	6
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	4	2	8
m. Training	5	2	10
n. Sensor Development	4	3	12
o. Operations	4	3	12

OVERALL PAYLOAD RANKING INDEX

140

Table 14

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) 1112

Payload Title: Space Station Four Persons - Earth Orbit

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	4	20
b. Calibration	3	1	3
c. Quality Assur- ance/Perform- ance Evaluation	5	3	15
d. Process Automa- tion	3	2	6
e. Growth Potential	4	3	12
f. Mission Planning	5	3	15
g. Data Analysis	3	2	6
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	3	2	6
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	4	2	8
m. Training	5	2	10
n. Sensor Development	4	3	12
o. Operations	4	3	12

OVERALL PAYLOAD RANKING INDEX

140

Table 15

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: (LS) 1036

Payload Title: Effect of Gravity on Life

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	4	2	8
c. Quality Assurance/Performance Evaluation	5	2	10
d. Process Automation	3	3	9
e. Growth Potential	3	3	9
f. Mission Planning	5	3	15
g. Data Analysis	5	3	15
h. Data Formatting	3	3	9
i. Coordination with Ancillary Data	4	3	12
j. Turnaround Time	2	2	4
k. Mission Usage Rates	3	2	6
l. Data Communication and Distribution	3	2	6
m. Training	5	2	10
n. Sensor Development	2	2	4
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

130

Table 16

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: (AP) AMPS

Payload Title: Atmospheric, Magnetospheric and Plasmas in Space

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	2	10
b. Calibration	4	2	8
c. Quality Assurance/Performance Evaluation	3	2	6
d. Process Automation	2	2	4
e. Growth Potential	3	2	6
f. Mission Planning	4	3	12
g. Data Analysis	5	4	20
h. Data Formatting	4	3	12
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	3	2	6
k. Mission Usage Rates	4	2	8
l. Data Communication and Distribution	3	2	6
m. Training	4	2	8
n. Sensor Development	3	2	6
o. Operations	4	2	8

OVERALL PAYLOAD RANKING INDEX

122

RANKING ASSESSMENT

Discipline: Planetary

Payload Code: PL-11 Venus Radar Mapper
 PL-13 Mercury Orbiter
 PL-19 Mariner Jupiter Orbiter
 PL-20 Pioneer Jupiter Probe
 PL-21 Mariner Saturn Orbiter
 (PL) 1090 Mars Polar Orbiter
 (PL) 1097 Neptune Orbiter

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Payload Title: Class IV. Planetary Orbiter with Imaging Science

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	4	2	8
b. Calibration	4	2	8
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	4	2	8
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	4	20
h. Data Formatting	4	3	12
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	3	1	4
k. Mission Usage Rates	4	1	4
l. Data Communication and Distribution	5	4	20
m. Training	4	1	4
n. Sensor Development	4	2	8
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

120

Table 18

RANKING ASSESSMENT

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Discipline: Life Sciences

Payload Code: (LS) 1040

Payload Title: Disease Processes Research

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	4	3	12
c. Quality Assur- ance/Perform- ance Evaluation	4	2	8
d. Process Automa- tion	4	3	12
e. Growth Potential	3	2	6
f. Mission Planning	5	3	15
g. Data Analysis	5	3	15
h. Data Formatting	3	3	9
i. Coordination with Ancillary Data	3	3	9
j. Turnaround Time	2	1	2
k. Mission Usage Rates	3	3	9
l. Data Communication and Distribution	3	1	3
m. Training	5	1	5
n. Sensor Development	2	3	6
o. Operations	5	1	5

OVERALL PAYLOAD RANKING INDEX

117

Table 19

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) ATL-3

Payload Title: Advanced Technology Laboratory

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	3	15
b. Calibration	5	2	10
c. Quality Assurance/Performance Evaluation	5	3	15
d. Process Automation	3	2	6
e. Growth Potential	3	3	9
f. Mission Planning	3	1	3
g. Data Analysis	4	1	4
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	4	2	8
k. Mission Usage Rates	3	3	9
l. Data Communication and Distribution	3	1	3
m. Training	3	2	6
n. Sensor Development	4	2	8
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

111

Table 20 .

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) ATL-1.

Payload Title: Advanced Technology Laboratory

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control.	5	3	15
b. Calibration	5	3	15
c. Quality Assur- ance/Perform- ance Evaluation	5	2	10
d. Process Automa- tion	2	1	2
e. Growth Potential	3	2	6
f. Mission Planning	3	1	3
g. Data Analysis	4	2	8
h. Data Formatting	4	2	8
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	4	2	8
k. Mission Usage Rates	3	3	9
l. Data Communication and Distribution	3	2	6
m. Training	3	1	3
n. Sensor Development	4	1	4
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

108

Table 21
RANKING ASSESSMENT

Discipline: Planetary

Payload Code: PL-7 Mars Surface Sample Return
 PL-8 Mars Satellite Sample Return
 (PL) 1078 Mercury Surface Sample Return
 (PL) 1079 Venus Surface Sample Return
 (PL) 1095 Mars Lander/Rover
 (PL) 1085 Asteroid Surface Sample Return
 (PL) 1086 Comet Surface Sample Return

Payload Title: Class II. Planetary Surface Sample Return
 Missions

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	4	20
b. Calibration	4	1	4
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	5	5	25
e. Growth Potential	1	1	1
f. Mission Planning	5	2	10
g. Data Analysis	4	1	4
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	1	1	1
j. Turnaround Time	4	2	8
k. Mission Usage Rates	4	1	4
l. Data Communication and Distribution	4	2	8
m. Training	4	1	4
n. Sensor Development	4	1	4
o. Operations	4	2	8

OVERALL PAYLOAD RANKING INDEX

108

Table 22

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: LS-02-A

Payload Title: Biomedical Experiments Scientific Satellite (BESS)

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	3	1	3
c. Quality Assurance/Performance Evaluation	4	2	8
d. Process Automation	5	3	15
e. Growth Potential	3	3	9
f. Mission Planning	5	3	15
g. Data Analysis	5	1	5
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	3	3	9
k. Mission Usage Rates	3	2	6
l. Data Communication and Distribution	3	2	6
m. Training	4	1	4
n. Sensor Development	1	2	2
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

108

Table 23

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: LS-09-S

Payload Title: Life Sciences Shuttle Laboratory

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	4	2	8
c. Quality Assur- ance/Perform- ance Evaluation	5	2	10
d. Process Automa- tion	3	3	9
e. Growth Potential	2	3	6
f. Mission Planning	5	2	10
g. Data Analysis	5	3	15
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	2	1	2
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	2	6
m. Training	5	2	10
n. Sensor Development	2	2	4
o. Operations	5	2	10

OVERALL PAYLOAD RANKING INDEX

108

Table 24
RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: LS-13-S

Payload Title: Life Sciences US/ESRO Spacelab

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	4	2	8
c. Quality Assur- ance/Perform- ance Evaluation	5	2	10
d. Process Automa- tion	3	3	9
e. Growth Potential	2	3	6
f. Mission Planning	5	2	10
g. Data Analysis	5	3	15
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	3	1	2
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	2	6
m. Training	5	2	10
n. Sensor Development	2	2	4
o. Operations	5	2	10

OVERALL PAYLOAD RANKING INDEX

108

RANKING ASSESSMENT

Discipline: Planetary

Payload Code: PL-15 Mariner Jupiter/Uranus Flyby
 PL-16 Pioneer Jupiter/Uranus Flyby
 PL-17 Pioneer Saturn Probe
 PL-18 Pioneer Saturn/Uranus Flyby (Uranus Probe)
 PL-22 Mariner Uranus/Neptune Flyby
 PL-31A Jupiter Swingby, Out-of-Ecliptic
 (PL) 1067 Interplanetary Near Sun Probe
 (PL) 1068 Solar System Escape Spacecraft
 (PL) 1071 Observatory in Solar Polar Orbit

Payload Title: Class III. Planetary Flyby with an Atmospheric Probe

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	4	2	8
b. Calibration	5	2	10
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	4	2	8
e. Growth Potential	1	1	1
f. Mission Planning	4	1	4
g. Data Analysis	4	2	8
h. Data Formatting	4	2	8
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	3	1	3
k. Mission Usage Rates	4	1	4
l. Data Communication and Distribution	5	4	20
m. Training	4	1	4
n. Sensor Development	4	1	4
o. Operations	4	1	4

Table 26

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: LS-04-S

Payload Title: Free Flyer Teleoperator

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Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	3	15
b. Calibration	1	1	1
c. Quality Assurance/Performance Evaluation	5	2	10
d. Process Automation	5	4	20
e. Growth Potential	3	3	9
f. Mission Planning	5	1	5
g. Data Analysis	5	1	5
h. Data Formatting	5	1	5
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	2	1	2
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	1	3
m. Training	5	2	10
n. Sensor Development	1	1	1
o. Operations	5	2	10

OVERALL PAYLOAD RANKING INDEX

103

Table 27

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) 1015

Payload Title: Hazard Waste System Operations

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	1	1	1
c. Quality Assurance/Performance Evaluation	5	3	15
d. Process Automation	3	2	6
e. Growth Potential	3	1	3
f. Mission Planning	5	4	20
g. Data Analysis	3	1	3
h. Data Formatting	3	1	3
i. Coordination with Ancillary Data	1	1	1
j. Turnaround Time	3	3	9
k. Mission Usage Rates	3	3	9
l. Data Communication and Distribution	3	2	6
m. Training	3	1	3
n. Sensor Development	1	1	1
o. Operations	5	4	20

OVERALL PAYLOAD RANKING INDEX

101

Table 28

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: (LS) 1039

Payload Title: Preliminary Disease Processes Research

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	4	3	12
c. Quality Assurance/Performance Evaluation	4	2	8
d. Process Automation	4	2	8
e. Growth Potential	3	2	6
f. Mission Planning	5	2	10
g. Data Analysis	5	3	15
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	2	1	2
k. Mission Usage Rates	3	2	6
l. Data Communication and Distribution	3	1	3
m. Training	5	1	5
n. Sensor Development	2	2	4
o. Operations	5	1	5

OVERALL PAYLOAD RANKING INDEX

97

Table 29

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) ATL-2

Payload Title: Advanced Technology Laboratory

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	2	10
b. Calibration	5	2	10
c. Quality Assurance/Performance Evaluation	5	2	10
d. Process Automation	2	1	2
e. Growth Potential	3	2	6
f. Mission Planning	3	1	3
g. Data Analysis	4	2	8
h. Data Formatting	4	2	8
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	4	2	8
k. Mission Usage Rates	3	3	9
l. Data Communication and Distribution	3	1	3
m. Training	3	1	3
n. Sensor Development	4	2	8
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

95

RANKING ASSESSMENT

Discipline: Planetary

Payload Code: PL-24 Dual Comet Flyby
 PL-25 Eneke Flyby
 PL-26 Eneke Rendezvous
 PL-27 Halley Flyby
 PL-28 Asteroid Rendezvous

Payload Title: Class V. Cometary Flyby or Rendezvous Missions

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	4	2	8
b. Calibration	4	2	8
c. Quality Assurance/Performance Evaluation	4	1	4
d. Process Automation	4	2	8
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	4	2	8
h. Data Formatting	4	2	8
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	3	1	3
k. Mission Usage Rates	4	1	4
l. Data Communication and Distribution	5	3	15
m. Training	4	1	4
n. Sensor Development	4	2	8
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

93

RANKING ASSESSMENT

Discipline: Planetary

Payload Code: PL-6 Viking Orbiter/Lander
 PL-12 Venus Buoyant Station
 PL-23 Jupiter Satellite Orbiter/Lander
 PL-28A Mars Penetrometer
 (PL) 1083 Titan Orbiter W/Penetrometer
 (PL) 1092 Titan Lander

Payload Title: Class I. Planetary Orbiter and Surface Probe Mission

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	4	2	8
b. Calibration	3	1	3
c. Quality Assurance/Performance Evaluation	3	1	
d. Process Automation	5	3	15
e. Growth Potential	2	1	2
f. Mission Planning	5	2	10
g. Data Analysis	4	2	8
h. Data Formatting	3	1	3
i. Coordination with Ancillary Data	4	3	12
j. Turnaround Time	3	1	3
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	4	1	4
m. Training	4	1	4
n. Sensor Development	3	2	6
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

88

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: LS-10-S

Payload Title: Life Sciences Minilabs

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	4	2	8
c. Quality Assur- ance/Perform- ance Evaluation	5	1	5
d. Process Automa- tion	3	3	9
e. Growth Potential	2	2	4
f. Mission Planning	5	2	10
g. Data Analysis	5	2	10
h. Data Formatting	3	1	3
i. Coordination with Ancillary Data	4	2	8
j. Turnaround Time	2	1	2
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	2	2	4
m. Training	5	1	5
n. Sensor Development	2	2	4
o. Operations	5	2	10

OVERALL PAYLOAD RANKING INDEX

86

Table 33

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: (LS) 1038

Payload Title: Human Performance in Space

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	4	1	4
c. Quality Assur- ance/Perform- ance Evaluation	5	2	10
d. Process Automa- tion	2	2	4
e. Growth Potential	2	2	4
f. Mission Planning	5	2	10
g. Data Analysis	5	2	10
h. Data Formatting	3	2	6
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	2	1	2
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	1	3
m. Training	5	2	10
n. Sensor Development	2	1	2
o. Operations	5	2	10
OVERALL PAYLOAD RANKING INDEX			83

Table 34

RANKING ASSESSMENT

Discipline: Solar Physics

Payload Code: SO-03-A

Payload Title: Solar Maximum Mission

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	4	1	4
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	2	2	4
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	2	10
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	3	1	3
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	2	6
m. Training	5	1	5
n. Sensor Development	2	2	4
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

69

Table 35

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: (SP) Silicon Ribbon

Payload Title: Free Flyer - Automated Silicon Ribbon Manufacturing Facility

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	5	1	5
c. Quality Assurance/Performance Evaluation	5	1	5
d. Process Automation	5	3	15
e. Growth Potential	5	2	10
f. Mission Planning	4	1	4
g. Data Analysis	2	1	2
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	2	1	2
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	2	1	2
m. Training	4	1	4
n. Sensor Development	3	1	3
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

67

Table 36

RANKING ASSESSMENT

Discipline: Space Technology

Payload Code: (ST) 1014

Payload Title: Hazard Waste System Development

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	1	1	1
c. Quality Assurance/Performance Evaluation	5	3	15
d. Process Automation	2	1	2
e. Growth Potential	3	1	3
f. Mission Planning	5	3	15
g. Data Analysis	3	1	3
h. Data Formatting	3	1	3
i. Coordination with Ancillary Data	1	1	1
j. Turnaround Time	1	1	1
k. Mission Usage Rates	1	1	1
l. Data Communication and Distribution	1	1	1
m. Training	3	1	3
n. Sensor Development	1	1	1
o. Operations	5	3	15

OVERALL PAYLOAD RANKING INDEX

64

Table 37

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP-08-A

Payload Title: Heliocentric and Interstellar Spacecraft

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	4	1	4
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	2	2	4
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	2	10
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	3	1	3
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	2	6
m. Training	4	1	4
n. Sensor Development	2	1	2
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

63

Table 38

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP-02-A

Payload Title: Medium Altitude Explorer

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	4	1	4
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	3	1	3
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	1	5
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	4	1	4
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	2	2	4
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

61

Table 39.

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP-01-A

Payload Title: Upper Atmospheric Explorer

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	4	1	4
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	3	1	3
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	2	10
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	4	1	4
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	2	1	2
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

61

Table 40

RANKING ASSESSMENT

Discipline: Life Sciences

Payload Code: LS-14-S

Payload Title: Animal Waste Carry-On

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	1	1	1
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	5	2	10
e. Growth Potential	2	2	4
f. Mission Planning	4	1	4
g. Data Analysis	1	1	1
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	3	2	6
j. Turnaround Time	1	1	1
k. Mission Usage Rates	1	1	1
l. Data Communication and Distribution	1	1	1
m. Training	5	2	10
n. Sensor Development	3	2	6
o. Operations	5	2	10

OVERALL PAYLOAD RANKING INDEX

60

Table 41

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: (AP) 1064

Payload Title: EOTVOS Effect Experiment-Spacelab Experiment

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	3	1	3
e. Growth Potential	3	1	3
f. Mission Planning	4	1	4
g. Data Analysis	4	1	4
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	3	1	3
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	3	2	5
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

59

Table 42

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP-07-A

Payload Title: Environmental Perturbation Satellite-B

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	4	1	4
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	3	1	3
e. Growth Potential	2	1	2
f. Mission Planning	4	2	8
g. Data Analysis	4	1	4
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	3	1	3
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	2	1	2
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

56

Table 43

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP-05-A

Payload Title: Environmental Perturbation Satellite-A

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	4	1	4
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	3	1	3
e. Growth Potential	2	1	2
f. Mission Planning	4	2	8
g. Data Analysis	4	1	4
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	3	1	3
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	2	1	2
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

56

Table 44

RANKING ASSESSMENT

ORIGINAL PAGE IS
OF POOR QUALITY

Discipline: Atmospheric and Space Physics

Payload Code: AP-03-A

Payload Title: High Altitude Explorer

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	4	1	4
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	3	1	3
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	1	5
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	4	1	4
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	2	1	2
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

56

Table 45

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP-04-A, B2

Payload Title: Gravity and Relativity Satellite

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	3	1	3
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	1	5
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	4	1	4
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	2	1	2
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

54

Table 46

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP04-A, B1

Payload Title: Gravity and Relativity Satellite

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	3	1	3
e. Growth Potential	1	1	1
f. Mission Planning	4	2	8
g. Data Analysis	5	1	5
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	4	1	4
j. Turnaround Time	4	1	4
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	3	1	3
m. Training	4	1	4
n. Sensor Development	2	1	2
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

54

Table 47

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: AP-06-A

Payload Title: Gravity and Relativity Satellite - Solar

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	5	1	5
c. Quality Assurance/Performance Evaluation	4	1	4
d. Process Automation	3	1	3
e. Growth Potential	1	1	1
f. Mission Planning	4	1	4
g. Data Analysis	3	1	3
h. Data Formatting	3	1	3
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	3	1	3
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	2	1	2
m. Training	4	1	4
n. Sensor Development	4	1	4
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

50

Table 48

RANKING ASSESSMENT

Discipline: Atmospheric and Space Physics

Payload Code: (AP) 1063

Payload Title: Gravity Wave Detector Free Flyer

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	5	1	5
b. Calibration	5	1	5
c. Quality Assurance/Performance Evaluation	2	1	2
d. Process Automation	3	1	1
e. Growth Potential	1	1	1
f. Mission Planning	4	1	4
g. Data Analysis	4	1	4
h. Data Formatting	4	1	4
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	3	1	3
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	2	1	2
m. Training	4	1	4
n. Sensor Development	4	1	4
o. Operations	4	1	4

OVERALL PAYLOAD RANKING INDEX

50

Table 49

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-31-S

Payload Title: First Spacelab Mission; Biological, Furnance
and Core

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	3	1	3
e. Growth Potential	3	1	3
f. Mission Planning	3	1	3
g. Data Analysis	4	1	4
h. Data Formatting	2	1	2
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	3	1	3
k. Mission Usage Rates	3	1	3
l. Data Communication and Distribution	3	1	3
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

44

Table 50

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-05-S

Payload Title: Space Processing Application No. 5, Module/Pallet
Low-g Processing of Biological and Technical Materials

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	3	2	3
e. Growth Potential	3	1	3
f. Mission Planning	3	1	3
g. Data Analysis	3	1	3
h. Data Formatting	2	1	2
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	3	1	3

OVERALL PAYLOAD RANKING INDEX

42

Table 51

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-13-S

Payload Title: Space Processing Application No. 13 Automatic
Levitation, Contact Free Processing Experiments with
Metals and Oxides

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	4	2	8
e. Growth Potential	3	1	3
f. Mission Planning	2	1	2
g. Data Analysis	3	1	3
h. Data Formatting	2	1	2
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	2	1	2
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

42

Table 52 -

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-12-S

Payload Title: Space Processing Application No. 12 Automated
Furnance, Low-g Processing Experiments with Metals and
Composite Materials

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	4	2	8
e. Growth Potential	3	1	3
f. Mission Planning	2	1	2
g. Data Analysis	3	1	3
h. Data Formatting	2	1	2
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	2	1	2
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

42

Table 53

RANKING ASSESSMENT

ORIGINAL PAGE 1
OF POOR QUALITY

Discipline: Space Processing

Payload Code: SP-19-S

Payload Title: Space Processing Application No. 19, Biological and
Automated Module/Pallet

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	4	1	4
e. Growth Potential	3	1	3
f. Mission Planning	3	1	3
g. Data Analysis	3	1	3
h. Data Formatting	2	1	2
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	2	1	2
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

41

Table 54

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-14-S

Payload Title: Space Processing Application No. 14, Automated
Module/Pallet

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	4	1	4
e. Growth Potential	3	1	3
f. Mission Planning	3	1	3
g. Data Analysis	3	1	3
h. Data Formatting	2	1	2
i. Coordination with Ancillary Data	3	1	3
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	2	1	2
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

41

Table 56

RANKING ASSESSMENT

Discipline: Space Processing PRECEDING PAGE BLANK NOT FILMED

Payload Code: SP-02-S

Payload Title: Space Processing Application No. 2, Furnance
Module/Pallet

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	3	1	3
e. Growth Potential	2	1	2
f. Mission Planning	3	1	3
g. Data Analysis	3	1	3
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	1	1	1
l. Data Communication and Distribution	1	1	1
m. Training	3	1	1
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

37

Table 57

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-16-S

Payload Title: Space Processing Application No. 16; Biological/
General, Low-g Processing Experiments on Biologicals,
Metals, Oxides & Low-g Fluid Mechanics

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	4	1	4
d. Process Automa- tion	2	1	2
e. Growth Potential	3	1	3
f. Mission Planning	3	1	3
g. Data Analysis	3	1	3
h. Data Formatting	2	1	2
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	2	1	2
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

36

Table 58

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-01-S

Payload Title: Space Processing Application No. 1, Biological
Module/Pallet

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	3	1	3
e. Growth Potential	2	1	2
f. Mission Planning	3	1	3
g. Data Analysis	3	1	3
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	1	1	1
l. Data Communication and Distribution	1	1	1
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

35

Table 59

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-03-S

Payload Title: Space Processing Application No. 3, Levitation
Module/Pallet

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	3	1	3
e. Growth Potential	2	1	2
f. Mission Planning	3	1	3
g. Data Analysis	3	1	3
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	1	1	1
l. Data Communication and Distribution	1	1	1
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

34

Table 60

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-04-S

Payload Title: Space Processing Application No. 4, General
Purpose Module/Pallet

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	3	1	3
e. Growth Potential	2	1	2
f. Mission Planning	2	1	2
g. Data Analysis	3	1	3
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	1	1	1
l. Data Communication and Distribution	1	1	1
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

33

Table 60

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-04-S

Payload Title: Space Processing Application No. 4, General
Purpose Module/Pallet

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assurance/Performance Evaluation	3	1	3
d. Process Automation	3	1	3
e. Growth Potential	2	1	2
f. Mission Planning	2	1	2
g. Data Analysis	3	1	3
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	1	1	1
l. Data Communication and Distribution	1	1	1
m. Training	3	1	3
n. Sensor Development	2	1	2
o. Operations	2	1	2

OVERALL PAYLOAD RANKING INDEX

33

Table 61

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-24-S

Payload Title: Space Processing Application No. 24, Minimum
Levitation Module, Contact-Free Processing of Oxides

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	2	1	2
e. Growth Potential	2	1	2
f. Mission Planning	2	1	2
g. Data Analysis	2	1	2
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	2	1	2
n. Sensor Development	1	1	1
o. Operations	1	1	1

OVERALL PAYLOAD RANKING INDEX

29

Table 62

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-23-S

Payload Title: Space Processing Application No. 23, Minimum
General Module, Research Experiments on Low-g Processing
of Materials

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assurance/Perform- ance Evaluation	3	1	3
d. Process Automation	2	1	2
e. Growth Potential	2	1	2
f. Mission Planning	2	1	2
g. Data Analysis	2	1	2
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	2	1	2
n. Sensor Development	1	1	1
o. Operations	1	1	1

OVERALL PAYLOAD RANKING INDEX

29

Table 63

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-22-S

Payload Title: Space Processing Application No. 22, Minimum
Furnance, Low-g Processing of Metals

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	2	1	2
e. Growth Potential	2	1	2
f. Mission Planning	2	1	2
g. Data Analysis	2	1	2
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	2	1	2
n. Sensor Development	1	1	1
o. Operations	1	1	1
OVERALL PAYLOAD RANKING INDEX			29

Table 64

RANKING ASSESSMENT

Discipline: Space Processing

Payload Code: SP-21-S

Payload Title: Space Processing Application No. 21, Minimum
Biological Module

Data System Related Payload Function	Need Index	Cost Index	Product Index
a. Pointing & Control	1	1	1
b. Calibration	5	1	5
c. Quality Assur- ance/Perform- ance Evaluation	3	1	3
d. Process Automa- tion	2	1	2
e. Growth Potential	2	1	2
f. Mission Planning	2	1	2
g. Data Analysis	2	1	2
h. Data Formatting	1	1	1
i. Coordination with Ancillary Data	2	1	2
j. Turnaround Time	2	1	2
k. Mission Usage Rates	2	1	2
l. Data Communication and Distribution	1	1	1
m. Training	2	1	2
n. Sensor Development	1	1	1
o. Operations	1	1	1

OVERALL PAYLOAD RANKING INDEX

29

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Table 65 Product Index Year Loading Profile

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3.0 Data Driver Analysis

The choice of data driver candidates involved consideration of four distinct elements: a) The position of the candidate in the overall payload ranking, as shown on Table 66, "Payload Ranking for SO, IS, PL, ST, SP, and AP"; b) the rank of the candidate payload in each of the data systems related payload functions as discussed in Section 3.1; c) the time profiles that characterize the set of candidates in terms of how well this data handling loading is representative for the implied TPM loading, and d) the magnitude of the associated data rates and pipeline data volumes characteristic of the payload candidate.

3.1 Ranking by Data System Related Function

For each of the 15 data system related functions, the associated product index for each payload permits ranking of payloads within each function. This in effect ranks payloads in order of the severity of the requirement for that function. These rankings are presented in tables 67 through 81. The sum of product indices for each function, in turn, provides a means of ranking the functions themselves. This ordering is an indicator of the priorities that need to be observed in developing these technology areas. this is shown in Table 82, "Functions Ordered by Product Index Sums".

3.2 The Candidate Data Drivers

From the ordered set of payloads shown in Table 66, the highest 21 were selected for closer scrutiny. One of several analyses performed is shown in Table 83, "Product Index Leaders by Function". Here the top ranking 21 payloads are shown with X's indicating functions for which this payload

TABLE - 67

a. POINTING & CONTROL

429

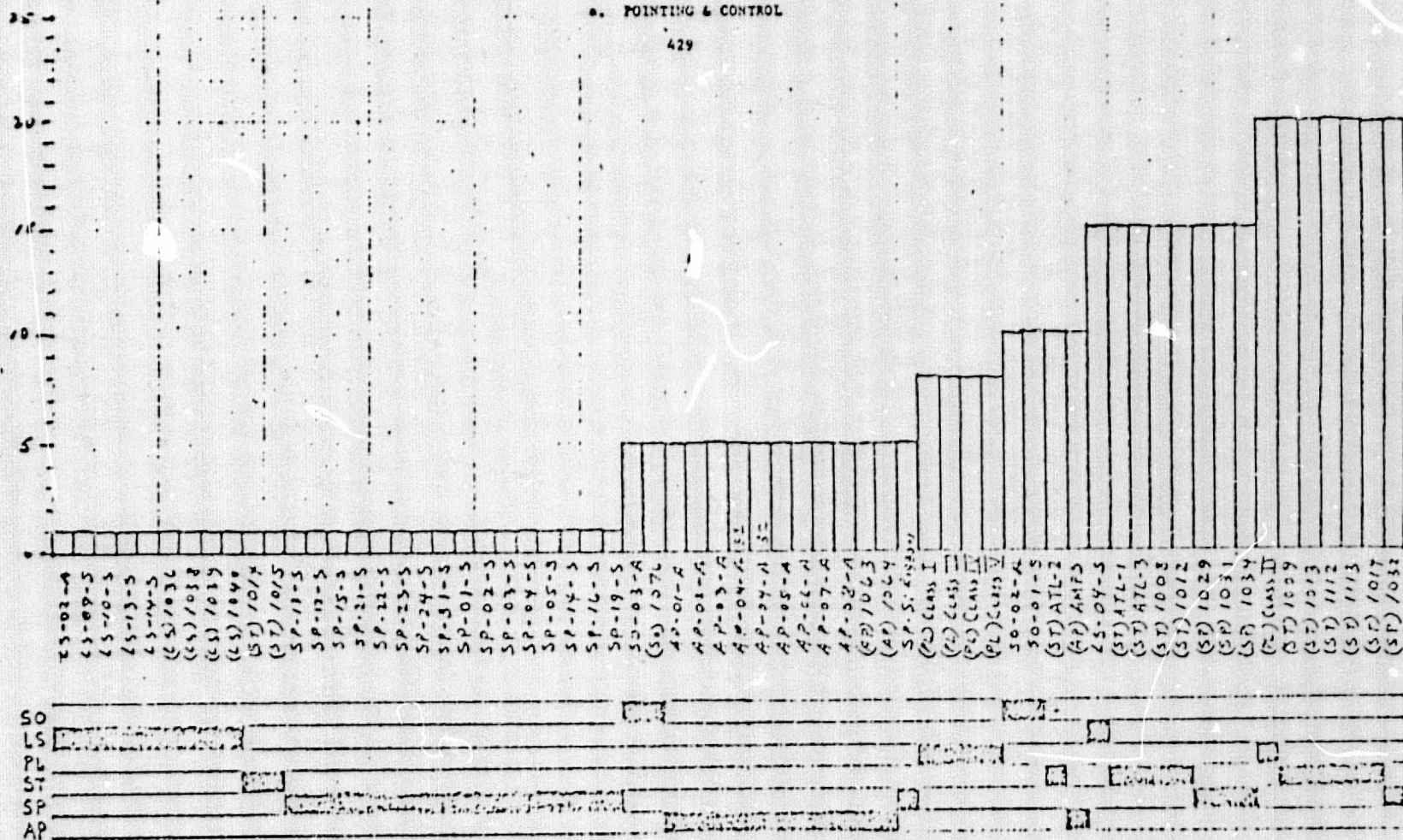


TABLE - 68

B. CALIBRATION

431

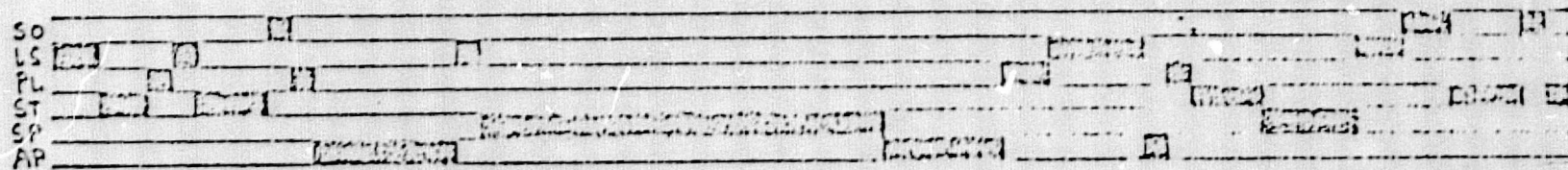
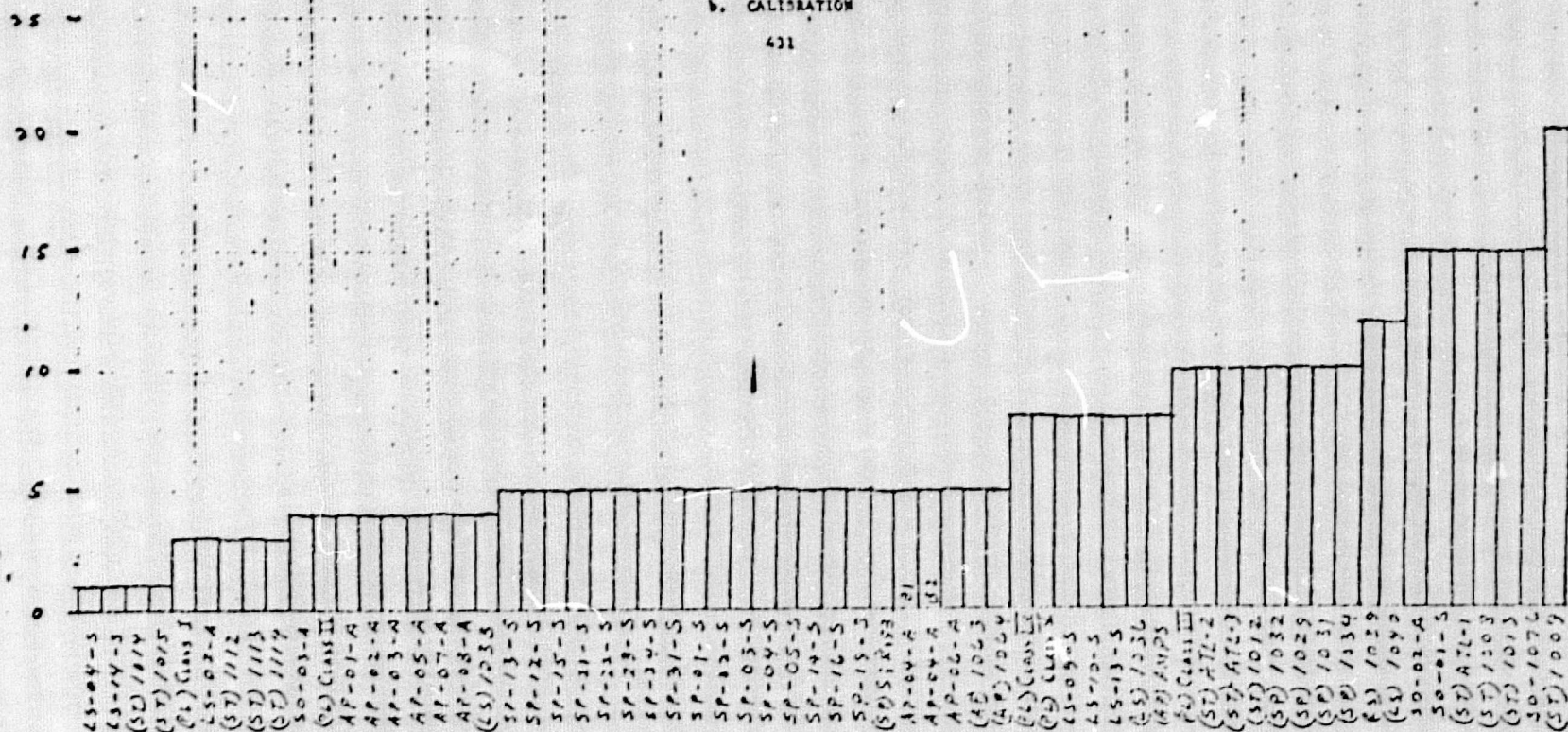
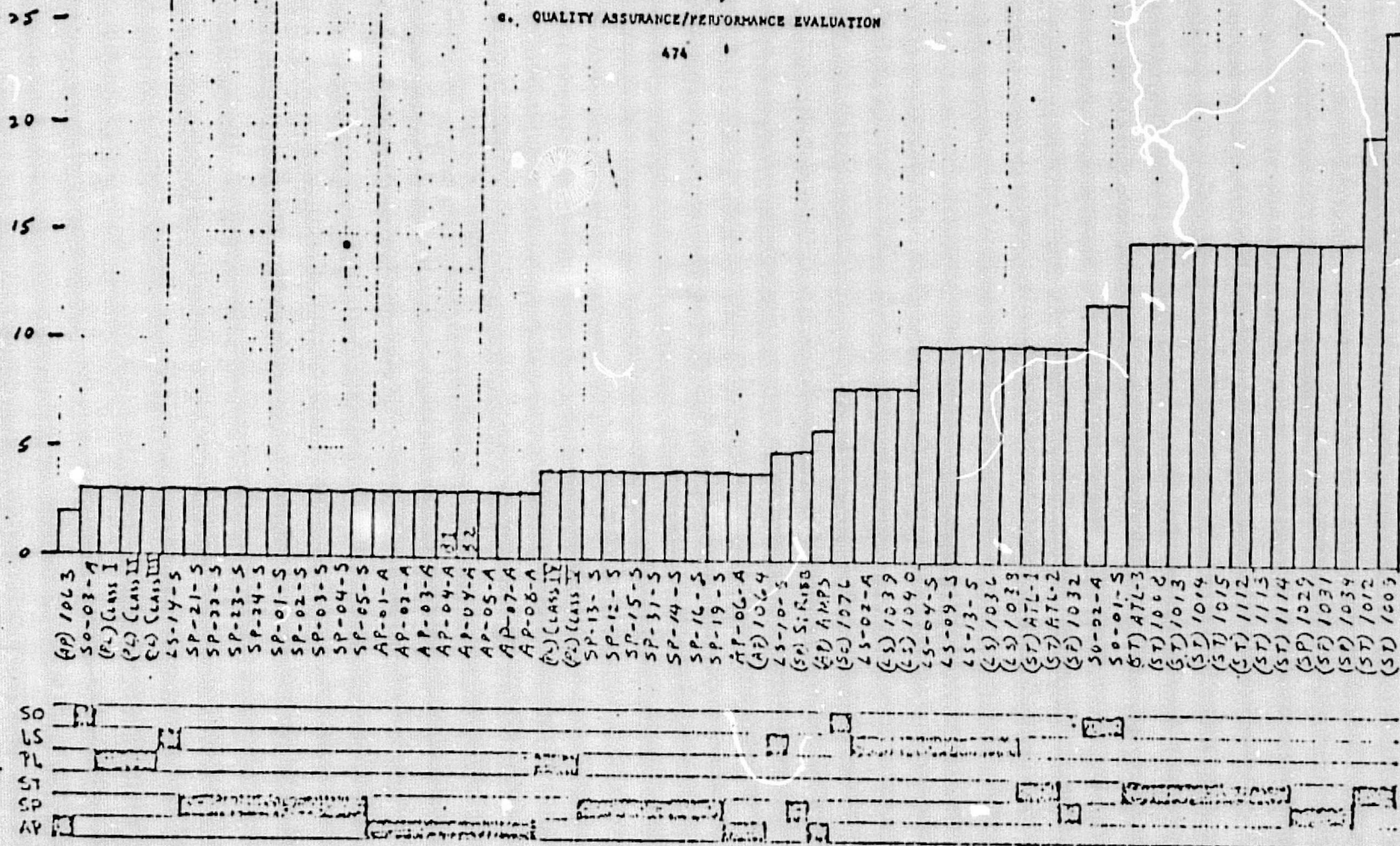


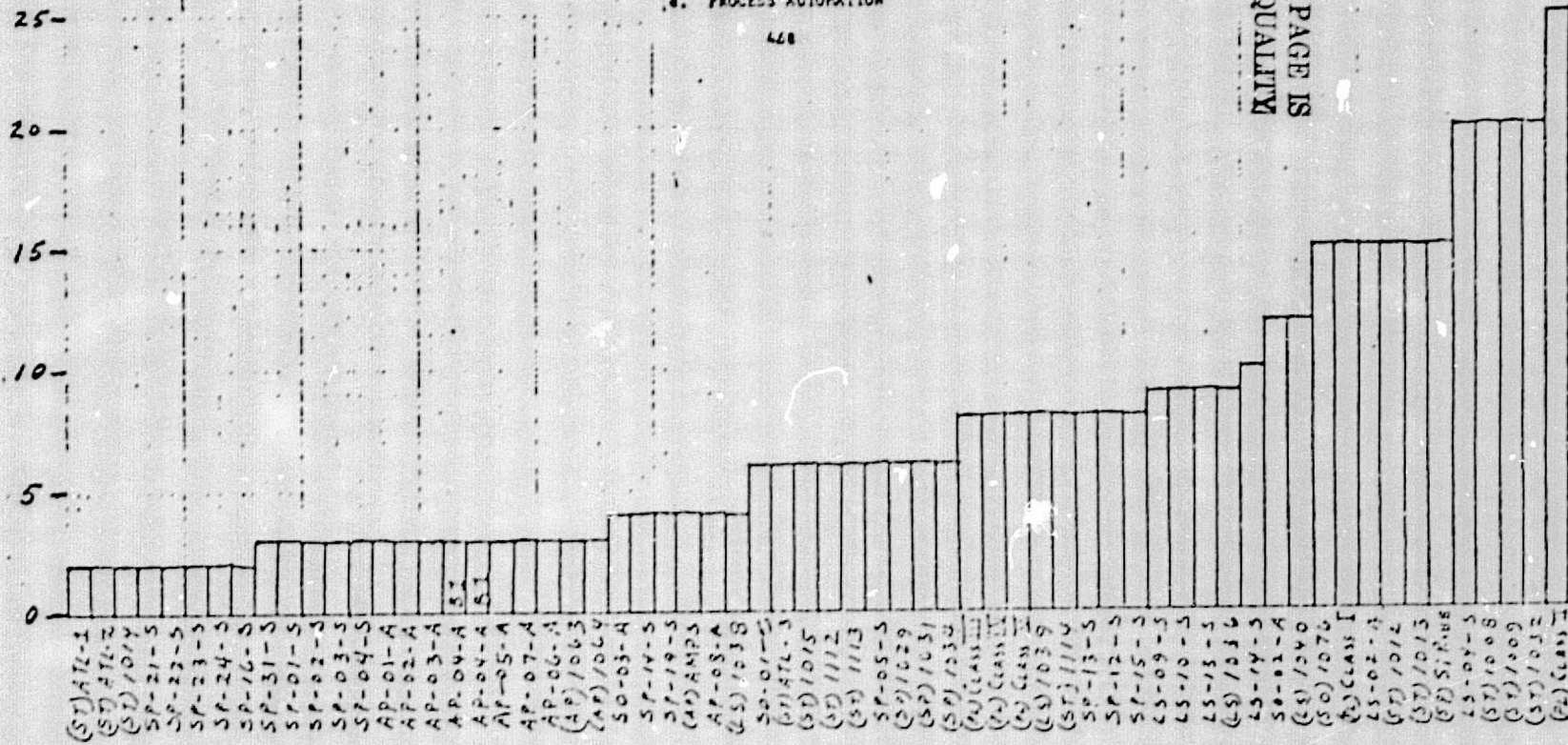
TABLE - 69
6. QUALITY ASSURANCE/PERFORMANCE EVALUATION
474



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TABLE - 70

4. PROCESS AUTOMATION



SO
LS
PL
ST
SP
AP

TABLE-71
GROWTH POTENTIAL

332

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25-
20-
15-
10-
5-
0

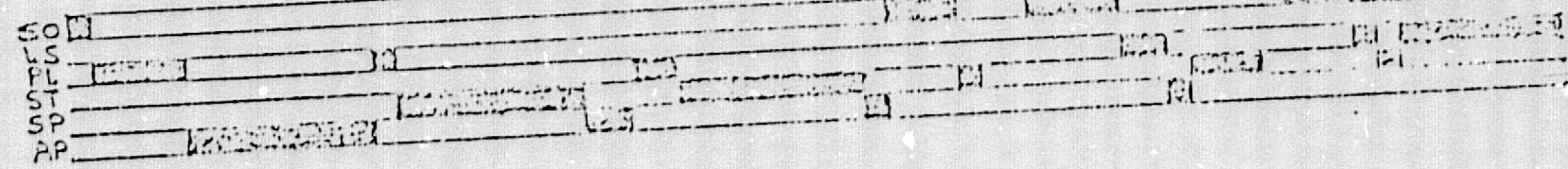
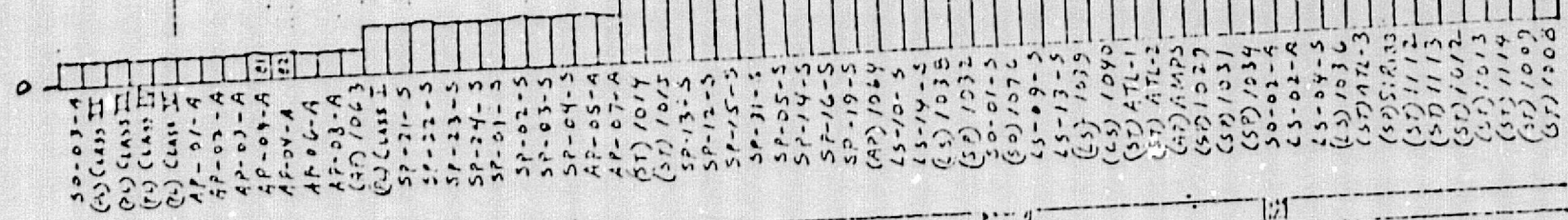


TABLE - 72

6. MISSION PLANNING

336

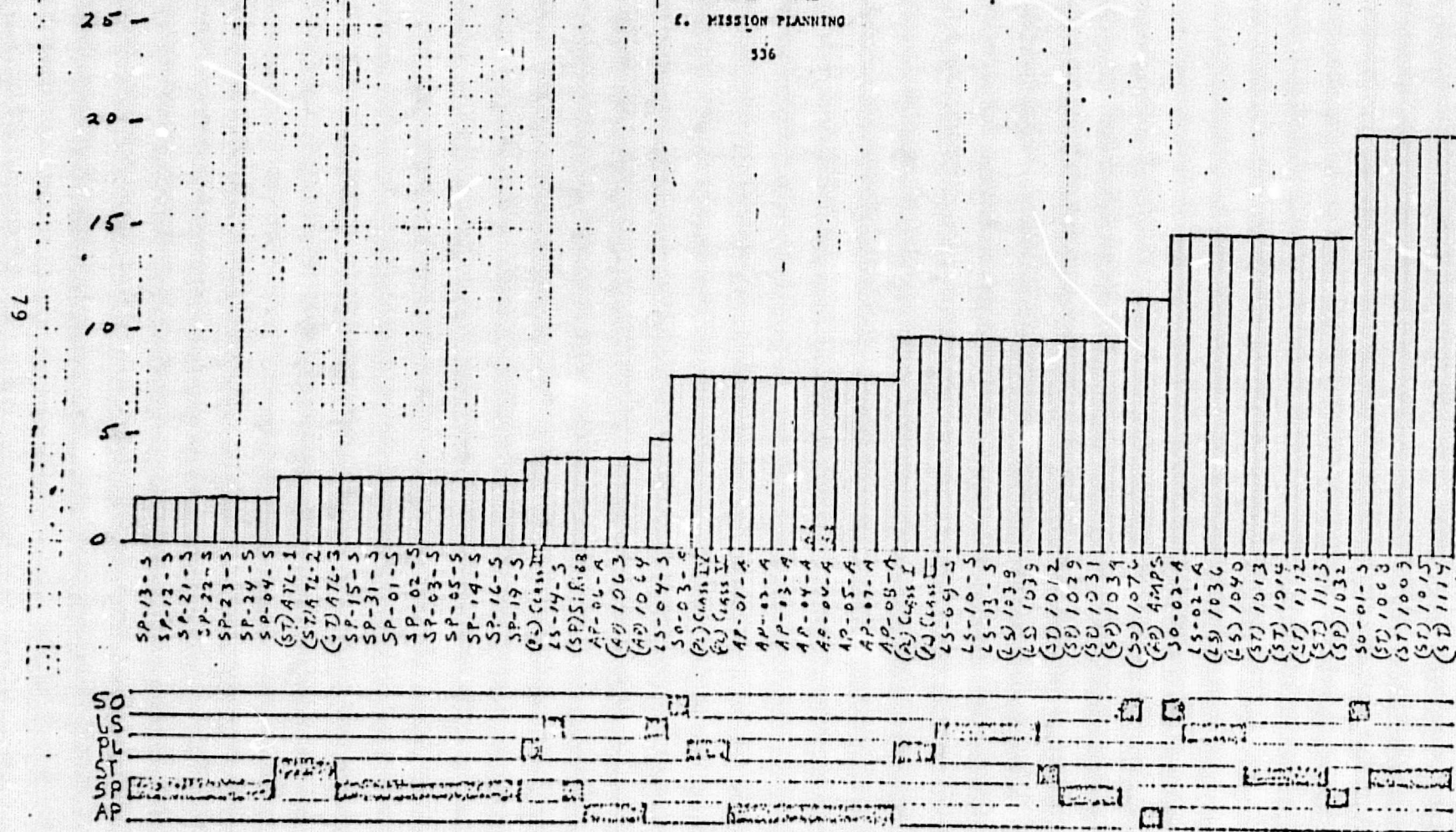
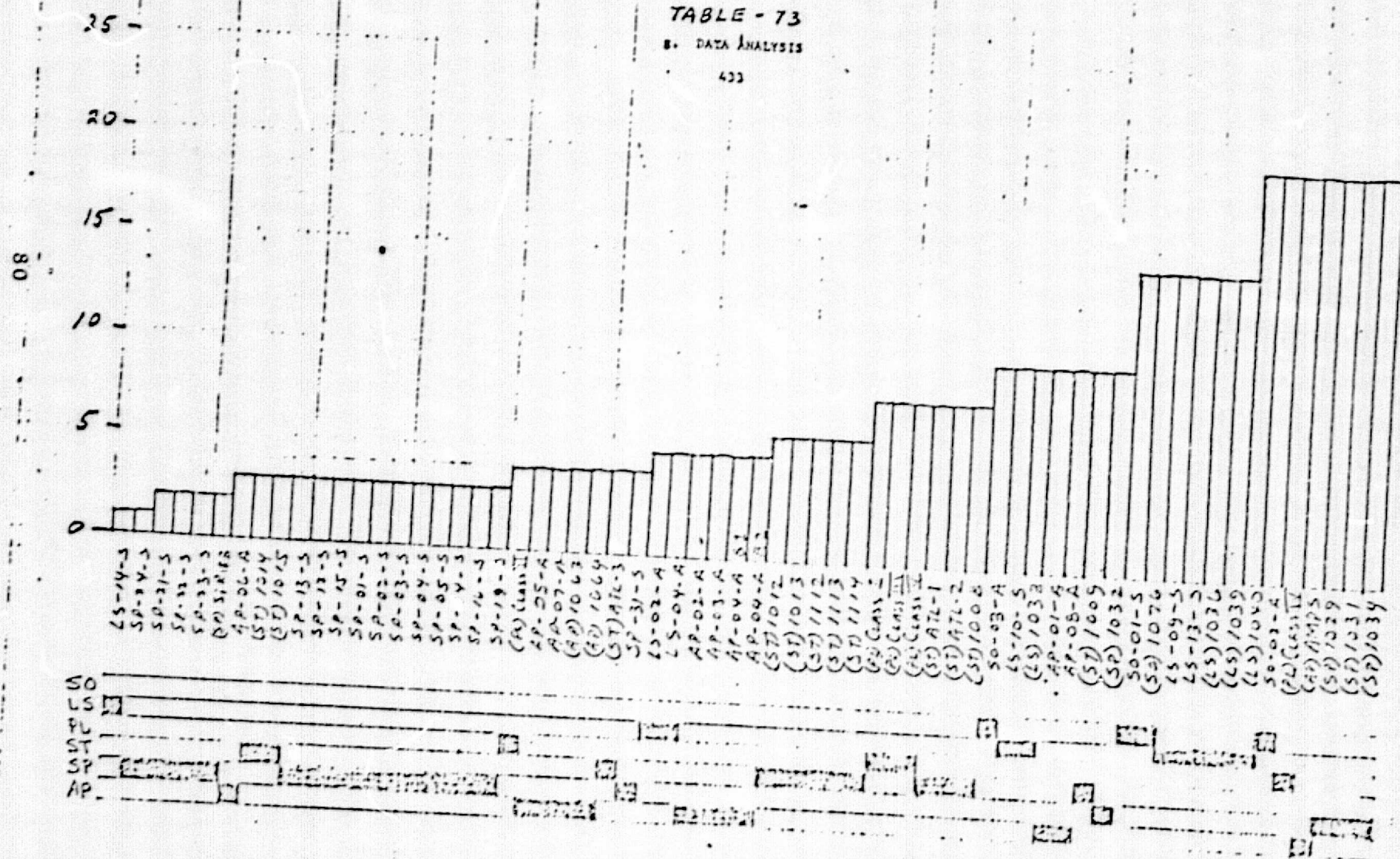


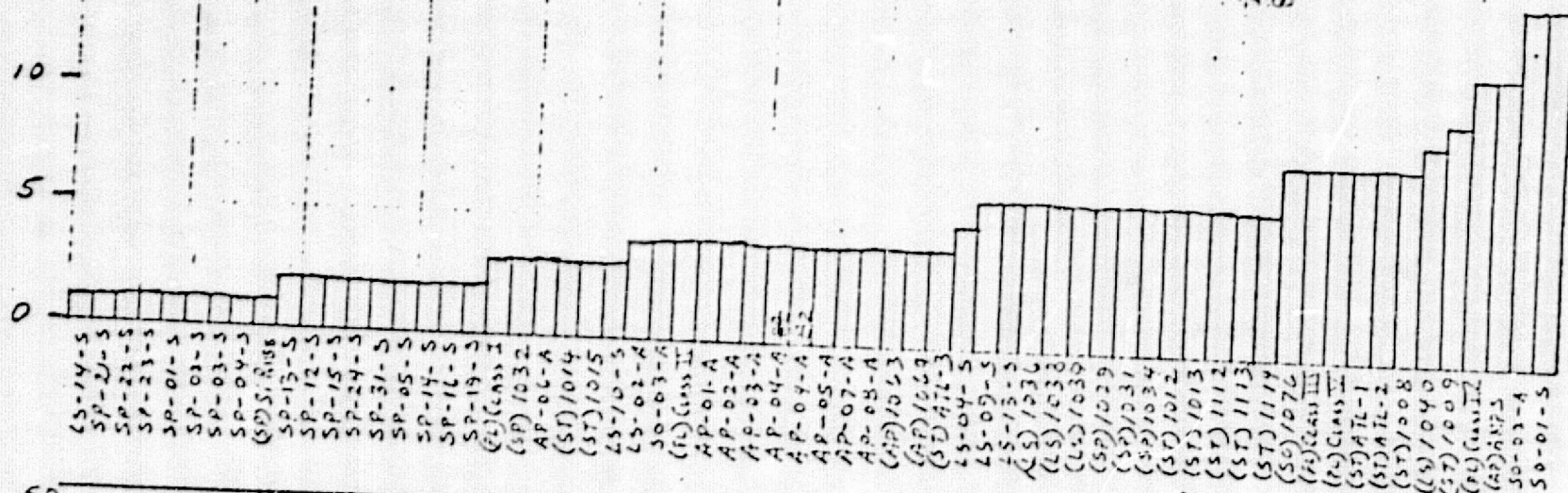
TABLE - 73
B. DATA ANALYSIS
422



h. DATA FORMAT

303

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TABLE - 75

1. COORDINATION WITH AUXILIARY DATA

335

82

25 -
20 -
15 -
10 -
5 -
0

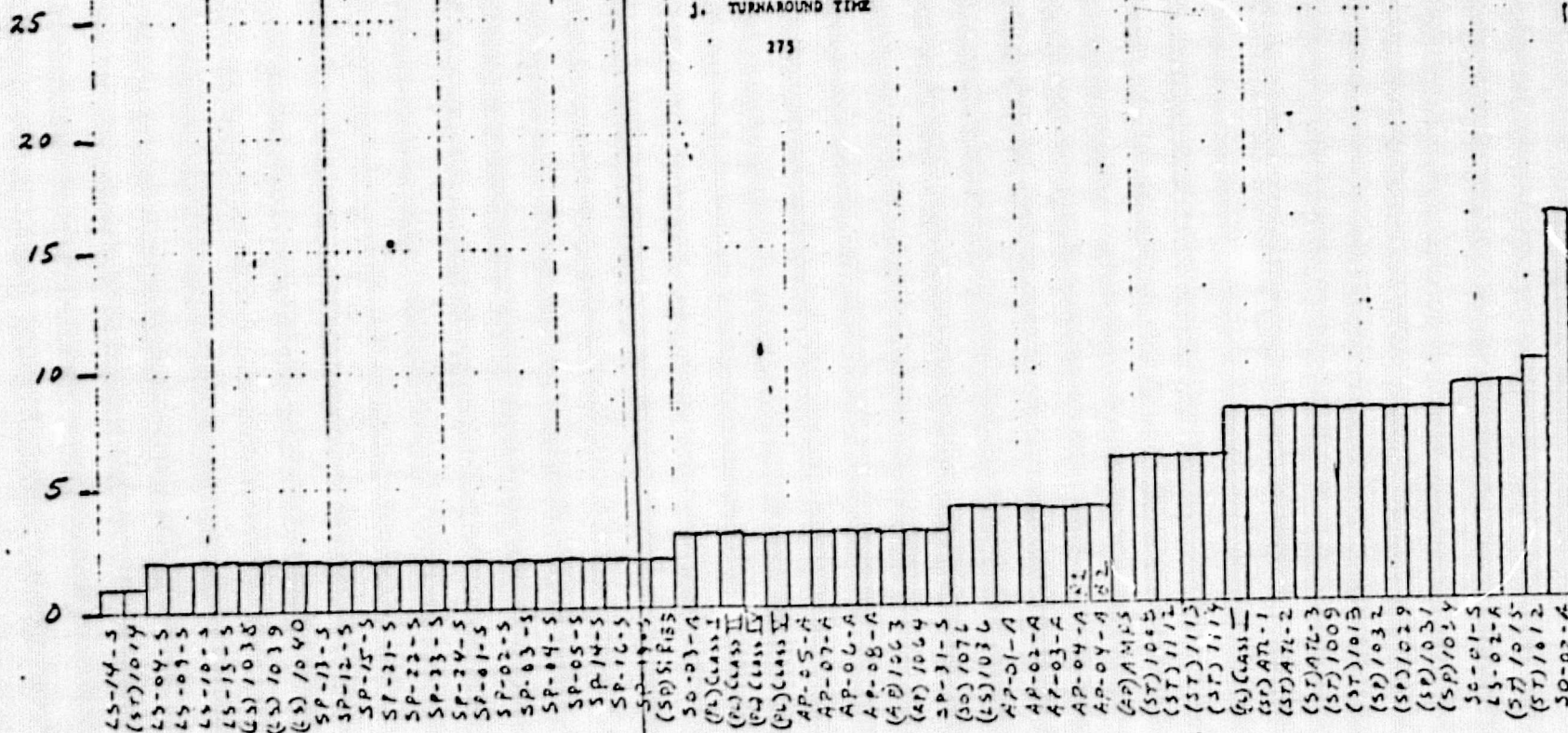
AP-01-1
AP-02-1
AP-03-1
AP-04-1
AP-05-1
AP-06-1
AP-07-1
AP-08-1
AP-09-1
AP-10-1
AP-11-1
AP-12-1
AP-13-1
AP-14-1
AP-15-1
AP-16-1
AP-17-1
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AP-89-1
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AP-91-1
AP-92-1
AP-93-1
AP-94-1
AP-95-1
AP-96-1
AP-97-1
AP-98-1
AP-99-1
AP-100-1

SO
LS
PL
ST
SP
AP

TABLE - 76

J. TURNAROUND TIME

173

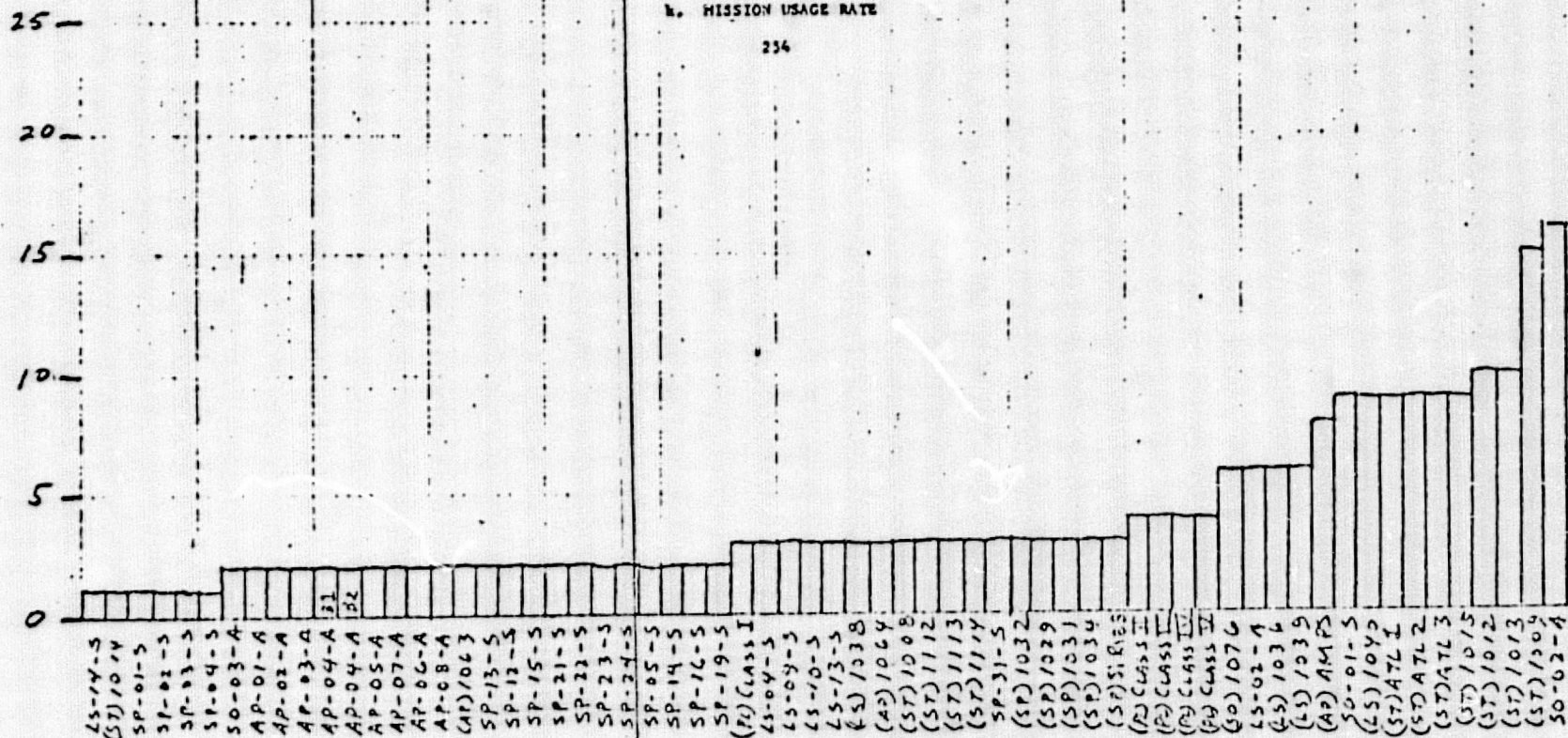


SO
LS
PL
ST
SP
AP

TABLE - 77

B. MISSION USAGE RATE

234



SO
LS
SP
ST
AP

TABLE - 78

2. DATA COMMUNICATION & DISTRIBUTION

217

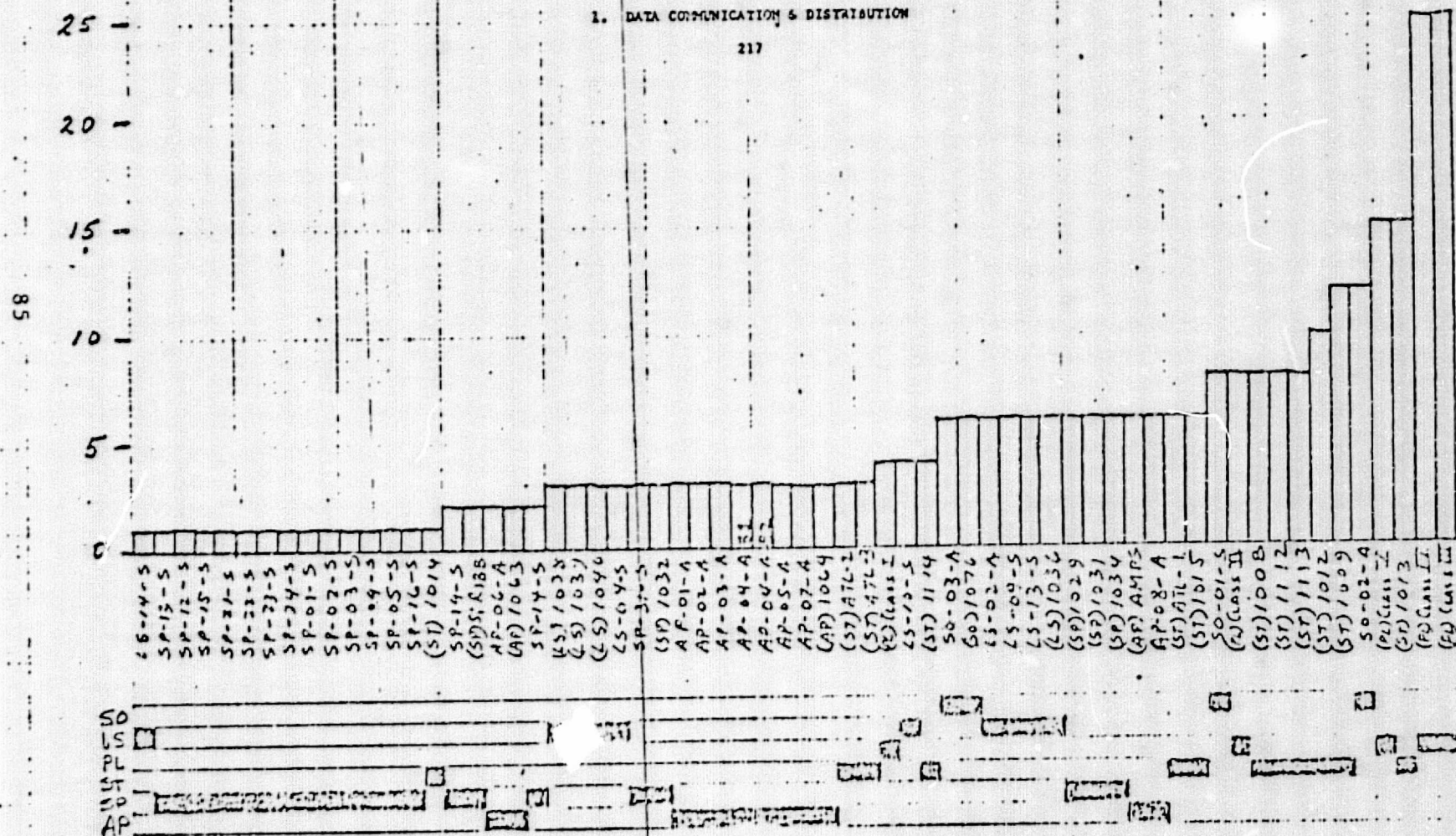
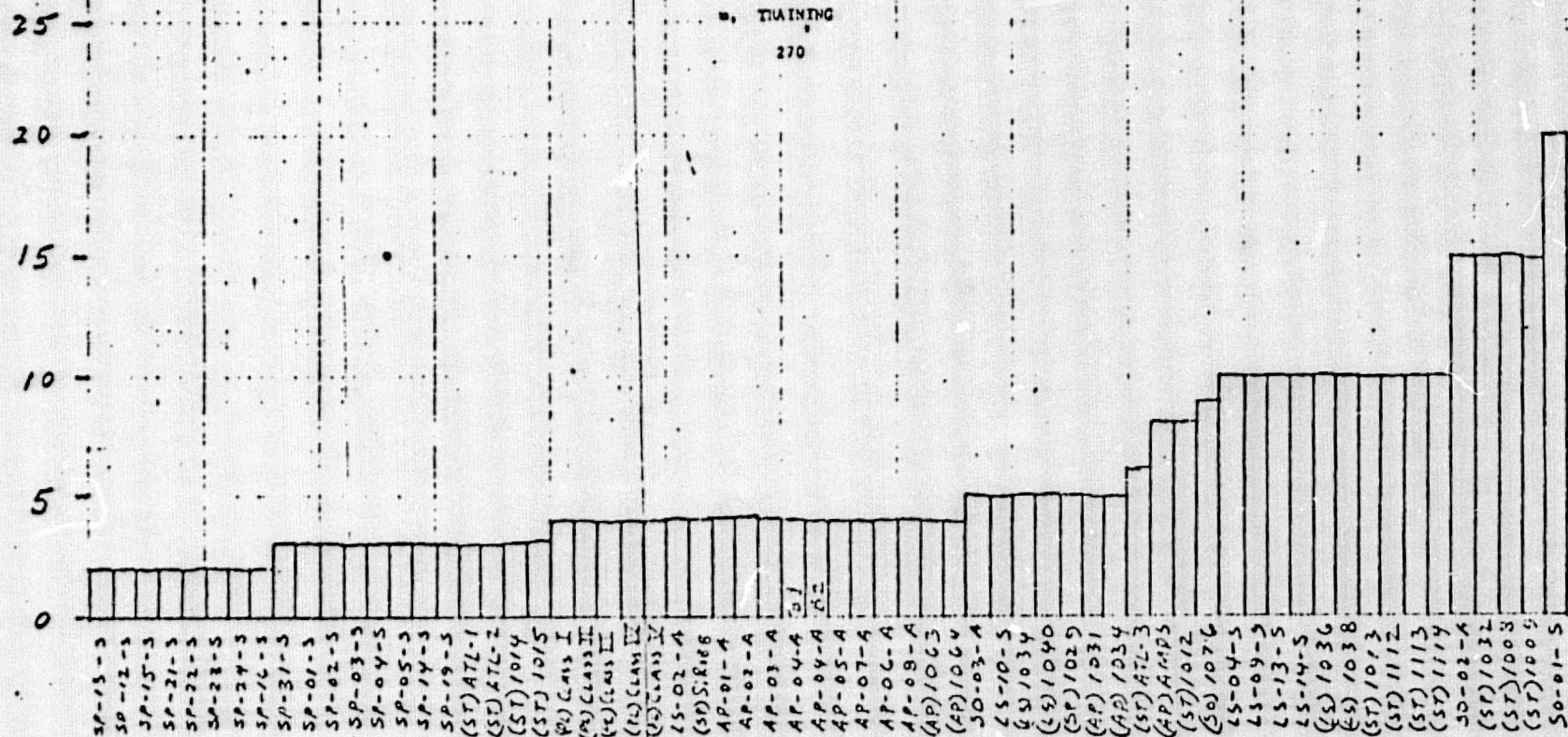


TABLE - 79

4. TRAINING

270



50
1.5
P2
ST
SP
AP

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TABLE - 80

SENSOR DEVELOPMENT

328

25 -
20 -
15 -
10 -
5 -
0

LS-04-3
(ST) 1014
SP-21-5
SP-22-5
SP-23-5
SP-24-5
LS-02-4
(LS) 1038
AP-01-A
AP-05-A
AP-07-A
SP-13-5
SP-12-5
SP-15-5
SP-31-5
SP-01-5
SP-02-5
SP-03-5
SP-04-5
SP-05-5
SP-14-5
SP-16-5
SP-19-5
AP-08-A
(SP) SiK155
SP-03-A
(PL) Cans III
(LS) Cans III
LS-05-5
LS-10-5
LS-13-5
(LS) 1036
(LS) 1039
AP-02-A
AP-03-K
AP-04-A 64
AP-04-A 82
AP-06-A
(AP) 1063
(ST) ATL-1
(LS) Cans I
LS-14-5
(LS) 1040
(AP) AMP5
(AP) 1064
(LS) Cans I
(LS) Cans I
(LS) ATL-2
(LS) 712-3
(LS) 1012
(LS) 1013
LS-02-05
LS-10-05
SP-01-05
(LS) 1005
(LS) 1005
(LS) 1112
(LS) 1113
(ST) 1117
(SP) 1029
(SP) 1031
(SP) 1134
(SP) 1032

SO
LS
PL
ST
SP
AP

403

SO
LS
PL
ST
SP
AP

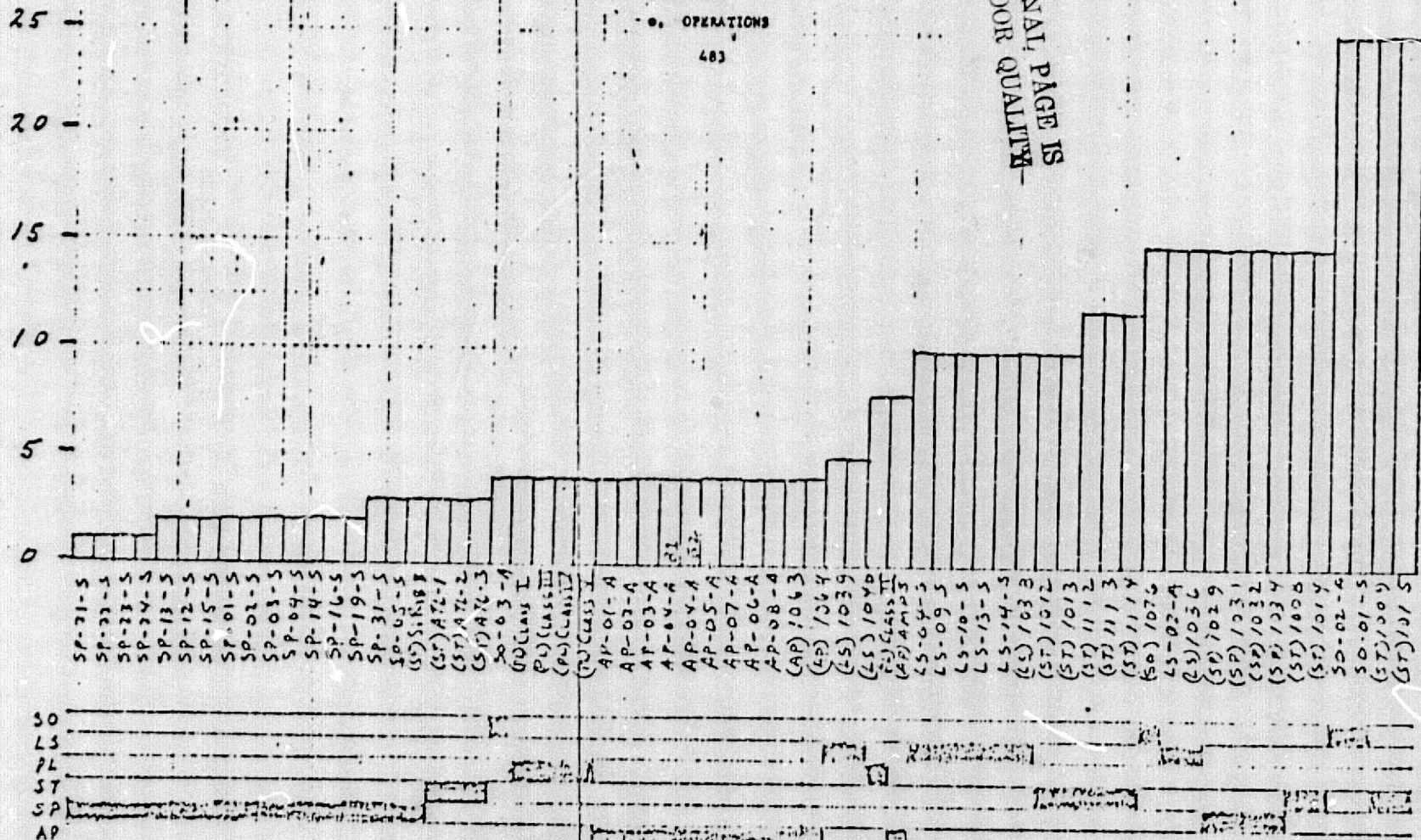


TABLE - 82
FUNCTIONS ORDERED BY PRODUCT INDEX SUMS

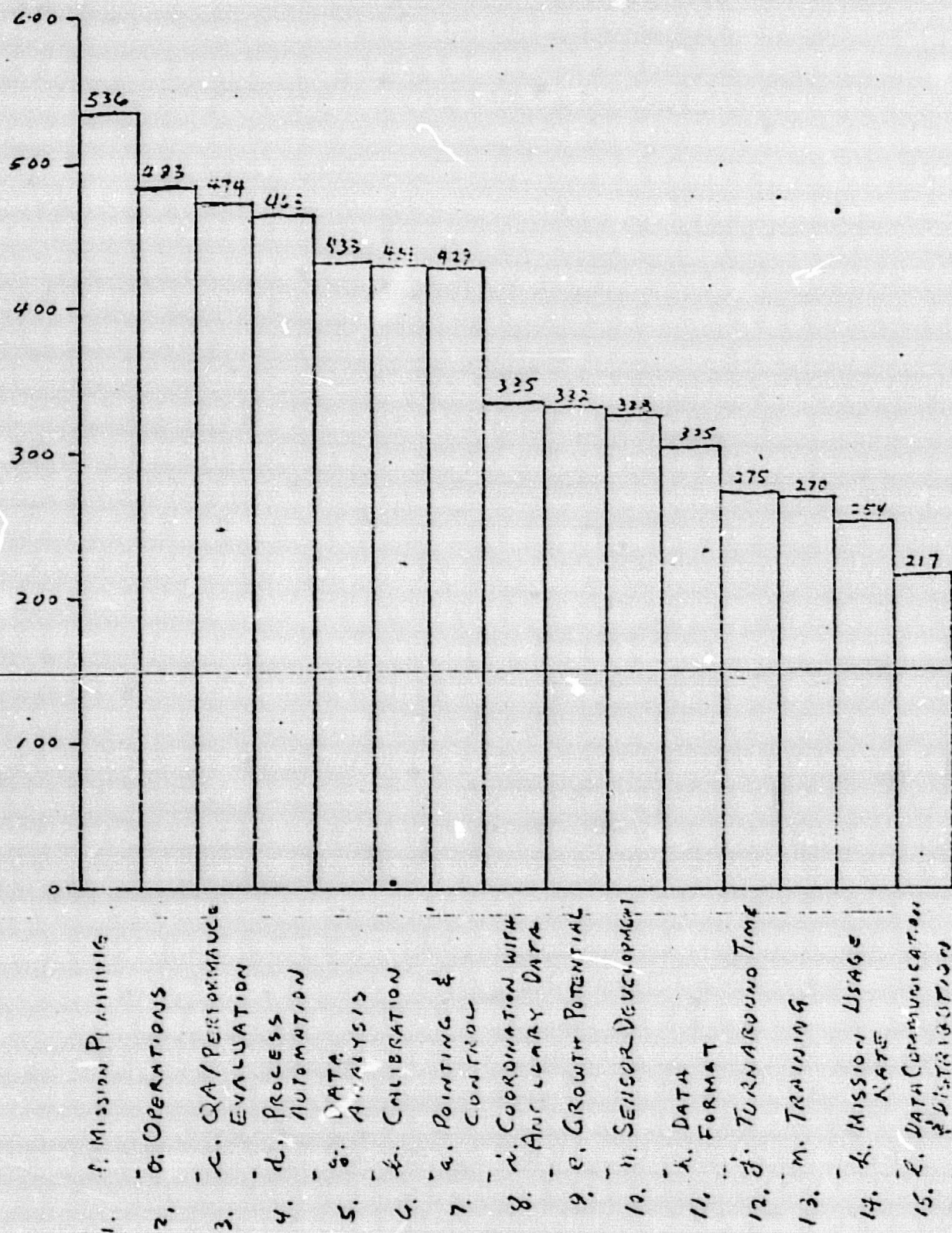


TABLE - 00

PRODUCT INDEX LEADERS BY FUNCTION

1. (ST) 1009
2. 50-02-A
3. (ST) 1008
4. 50-01-S
5. (ST) 1013
6. (ST) 1012
7. (SP) 1032
8. (ST) 1114
9. (SP) 1039
10. (SP) 1031
11. (SP) 1029
12. (SO) 1076
13. (ST) 1113
14. (ST) 1112
15. (LS) 1036
16. (AP) AMP5
17. (PL) C-IV
18. (LS) 1040
19. (ST) ATL-3
20. (ST) ATL-1
21. (PL) C-II

	POINTING & CONTROL	CALIBRATION	QA / PERF. EVALUATION	PROCESS AUTOMATION	GROWTH POTENTIAL	MISSION PLANNING	DATA ANALYSIS	DATA FORMAT	COORD. WITH ANCILLARY DATA	TURNAROUND TIME	MISSION USAGE RATE	DATA COMMUNICATION & DISTRIBUTION	TRAINING	SENSOR DEVELOPMENT	OPERATIONS
	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.	n.	o.
1.	X	X	X							X	X	X			X
2.						X	X								X
3.							X		X				X		
4.															
5.	X														
6.		X													X
7.							X								
8.								X							
9.								X							
10.								X							
11.										X					
12.															
13.	X	X													
14.										X					
15.								X							
16.	X							X					X		
17.								X							
18.															
19.															
20.															
21.						X									

obtained the highest product index, as compared to other payloads. For some functions (such as Pointing and Control, Mission Planning, etc.) several payloads had the same high product index value. In this case, all such payloads are identified here as "leaders". In other cases, such as for calibration, a single leader is identified because this payload had a product index that was higher than any other payload. The criteria of lead rank in at least one of the functions was applied to the candidate list. On this basis, (ST) 1012, (ST) ATL-3, and (ST) ATL-1 were eliminated from the list. The technological development for (ST) 1013 was seen to be fulfilled if the support requirements for (ST) 1009 were met and so (ST) 1013 was eliminated. Three payloads, (SP) 1034, (SP) 1031 and (SP) 1029 were observed to behave identically under all analyses performed and so (SP) 1031 and (SP) 1029 were eliminated and (SP) 1034 was allowed to remain on the list as representative for all three. The 12th ranking payload, (SO) 1076 is a 50 Kg carry-on experiment and this was deemed an unlikely driver candidate due to the low priority this category of payloads merits in terms of technology development. Therefore (SO) 1076 was removed from the list. Three space station entries, (ST) 1114, (ST) 1113 and (ST) 1112 were deemed redundant and therefore (ST) 1114 was allowed to remain as represented for (ST) 1112 and (ST) 1113 which were eliminated. The 15th ranking payload, (LS) 1036, is characterized by very low data rates and data volumes, scored relatively low for most of the functions and represented a weak "leader" at best in a single function "coordination with Ancillary Data". For this reason, (LS) 1036 was also eliminated. The 18th ranking payload (LS) 1040, is very similar to (LS) 1036 in some respects, however it was allowed to remain on the list as representative of the Life Sciences payload and because so very little is known about this payload that it seemed judicious not to eliminate it prematurely.

The payloads that emerged as potential driver payloads are shown in Table 84, "Driver Candidate List".

These payloads were then examined in terms of the time profiles given by Table 65, "Product Index Yearly Loading Profile". It was observed that the set of candidate drivers constituted a significant fraction of the yearly product index loading for the latter half of the 1980's decade and it was concluded that the candidate set was representative in terms of payload support requirements over this period. It was also observed that the candidate set included SO-02-A, SO-01-S and (AP) AMPS which are the payloads with the heaviest data rates and data volumes identified thus far for the disciplines covered.

3.3 Driver Candidate List

The product index leader status for each of these driver candidates corresponds generally to those characteristics that contribute to their high ranking.

1. TPM Number: (ST) 1009

Solar Power Prototype Development

This prototype activity includes the launch assembly and initial operation in geosynchronous orbit of a solar power station intended to provide a final and realistic evaluation of the feasibility and economic viability of providing solar power via satellites.

Lead rank for Pointing and Control was due to the need to maintain control of the radiating array alignment to within a few centimeters over a 1 kilometer distance as well as the need to control RF beam pointing to within several hundred meters on the ground from geosynchronous altitudes. Calibration function lead is attributed to precise input sensor calibration for automated shape control of very large structures.

TABLE - 84 DRIVER CANDIDATE LIST

		a. POINTING & CONTROL	b. CALIBRATION	c. QA/PERF. EVAL.	d. PROCESS AUTOMATION	e. GROWTH POTENTIAL	f. MISSION PLANNING	g. DATA ANALYSIS	h. DATA FORMAT	i. COORD. WITH ANCILIARY DATA	j. TURNAROUND TIME	k. MISSION USAGE RATE	l. DATA COMM. & DIST.	m. TRAINING	n. SENSOR DEVELOPMENT	o. OPERATIONS
(ST) 1009	SSPS	X	X	X			X									X
50-02-A	LARGE SOLAR OBS.							X	X	X	X	X				X
(ST) 1008	SSPS - TEST				X	X										
50-01-S	DSSM					X			X					X		X
(SP) 1032	COMMERCIAL PROCESSING	X													X	
(ST) 1114	GEO SYNCH. SPACE STA.				X											
(SP) 1034	MATERIALS RESEARCH							X								
(AP) AMPS								X								
(PL) CLASS IV	PLANETARY ORBITERS							X					X			
(LS) 1040	DISEASE PROCESSES							X								
(PL) CLASS II	SAMPLE RETURN	X		X												

7/22/76

Quality Assurance/Performance Evaluation lead resulted from QA requirements for the manufacture and maintenance of a 10 G watt power station.

Mission planning lead came from the need to support very large work forces in space logistics, and support and design very large space structures. The same requirements led to a lead in Operations.

2. TPM Number: SO-02-A

Large Solar Observatories

This facility will be installed in 1985 and will be revisited yearly thereafter. The experiment complement is as follows:

EXPERIMENTS LIST:

SO-001	Externally Occulted Coronagraph Film and TV Image
SO-002	100 cm (150 cm) Photoheliograph
SO-003	Ultraviolet Spectrograph
SO-004	EUV Spectroheliometer
SO-005	Extreme Ultraviolet (XUV) Spectroheliograph
SO-020	Soft X-Ray Telescope/Spectrograph
SO-007	Soft X-Ray Spectrometer/Spectrograph
SO-008	Grid Collimator Acquisition Photometer
SO-011	Solid State Flare Detector
SO-012	X-Ray Burst Detector
SO-013	X-Ray/Gamma Ray Spectrometer
SO-014	Gamma Ray Spectrometer
SO-015	Solar X-Ray Polarimeter
SO-016	Bragg Reflection Crystal Polarimeter
SO-017	Solar Neutron Experiment
SO-018	High Energy Gamma Ray and Neutron Detector

Lead position for the Data Analysis function was due to high bit rates, large daily data volumes and substantial image processing characteristic for this payload. Data Format lead resulted from the fact that the data acquisition process for some experiments does not produce the final data block arrangement needed for data analysis. The Coordination with Ancillary Data lead comes from the fact that correlation of multi-band imagery is basic to understanding solar phenomenology. Turnaround Time lead is associated with the fact that the distribution of life cycle times for solar phenomena is such that significant increased in observational opportunities result for shortened turn-around times. Characteristic high bit rates for some of the constituent experiments and high duty cycles yield a lead in Mission Usage Rate. The large instrument complement and high duty cycles require substantial ground control support resulting in a lead for Operations.

3. TPM Number: (ST) 1008

Solar Power Space Test Activity

This activity would be built around a Shuttle supported activity and gradually evolve into a permanent facility to support the assembly of prototype or operational solar power satellites.

System growth is one of the key goals for this project making it a leader in Growth Potential. A large work force building a large space structure results in a Mission Planning lead.

4. TPM Number: SO-01-S

Dedicated Solar Sortie Mission (DSSM)

The DSSM missions will be of seven day duration (5 days of data acquisition). One mission per year will be flown in 1980, 1981 and 1982 and twenty two additional DSSM's will be flown in the period between 1983 and 1991.

The experiment complement is the same as for SO-02-A given above in item 2. Planning data acquisition requires for the large experiment complement results in Mission Planning lead. The Data Format lead results from the fact that the data acquisition process for some experiments does not produce the final data block arrangement needed for data analysis. The large instrument complement and high duty cycles require substantial ground control support resulting in leads for Training and Operations.

5. TPM Number: (SP) 1032

Commercial Processing, Crew-Operated

Special purpose space station for the routine processing of products found by low-g research in the areas of chemistry, biology and materials research to have space-processing economic advantage or uniqueness.

A lead in Pointing and Control results from the need for maintaining a near-zero acceleration environment for long continuous periods of time. Totally new instrumentation concepts are needed for space processing and the computerized analysis for this development results in a lead for Sensor Development.

6. TPM Number: (ST) 1114

12-Person Geosynchronous Orbit Space Station

This project results in permanent inhabited stations launched into geosynchronous orbits.

The lead in Mission Planning came from the need for planning crew activities and data acquisition profiles for geosynchronous manned operations.

7. TPM Number: (SP) 1034

"Long Term" Biological Materials Research

This candidate also represents (SP) 1031 - "Long Term" Low-g Material Science Research and (SP) 1029 - "Long Term" Physical Chemical Research. These three projects will be carried out utilizing space station experimental packages. A lead in data analysis resulted from the fact that advanced instrument technology and automation produce more data and better and more samples in even shorter times, thereby necessitating sophisticated mechanization of data analysis in order to cope with the "data glut".

8. TPM Number: (AP) AMPS

Atmospheric, Magnetospheric and Plasmas in Space

The AMPS payload is a Shuttle sortie payload that will carry out experimental data acquisition for global remote sensing of the atmosphere, the ionosphere and the magnetosphere. This is done with a relatively large complement of instruments some of which exhibit high data rates and high-duty cycles. This results in a lead for Data Analysis.

9. Category: (PL) Class IV

Planetary Orbiter with Imaging Science

This is a composite category made up of the following TPM line items:

TPM Numbers	Title
PL-11	Venus Radar Mapper
PL-13	Mercury Orbiter
PL-19	Mariner Jupiter Orbiter
PL-20	Pioneer Jupiter Orbiter
PL-21	Mariner Saturn Orbiter
(PL) 1090	Mars Polar Orbiter
(PL) 1097	Neptune Orbiter

High resolution images, long transmission distances and low signal to noise ratios result in leads for Data Analysis and Data Communication and Distribution.

10. TPM Number: (LS) 1040

Disease Processes Research

The purpose of this facility is to promote a better understanding of physiology and disease in man. Two potentially fruitful lines of research are: (1) determine the mechanisms of the observed zero-gravity changes in the absence of underlying pathology (e.g., bone demineralization, loss of red cells); (2) observe the zero-gravity time course of selected diseases in human or animal subjects.

A lead in Data Analysis resulted from the fact that advanced instrument technology and automation produces more data and better and more samples in even shorter times, thereby necessitating sophisticated mechanization of data analysis in order to cope with the "data glut".

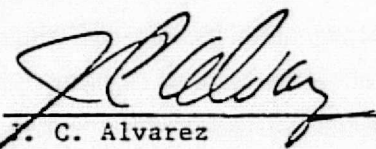
11. Category: (PL) Class II

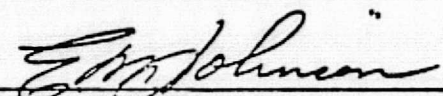
Planetary Surface Sample Return Missions

This is a composite category made up of the following TPM line items:

TPM Number	Title
PL-7	Mars Surface Sample Return
PL-8	Mars Satellite Sample Return
(PL) 1078	Mercury Surface Sample Return
(PL) 1079	Venus Surface Sample Return
(PL) 1095	Mars Lander/Rover
(PL) 1085	Asteroid Surface Sample Return
(PL) 1086	Comet Surface Sample Return

A lead in Pointing and Control derived from the fact that automated guidance and rendezvous operations require advanced pointing and control systems.


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